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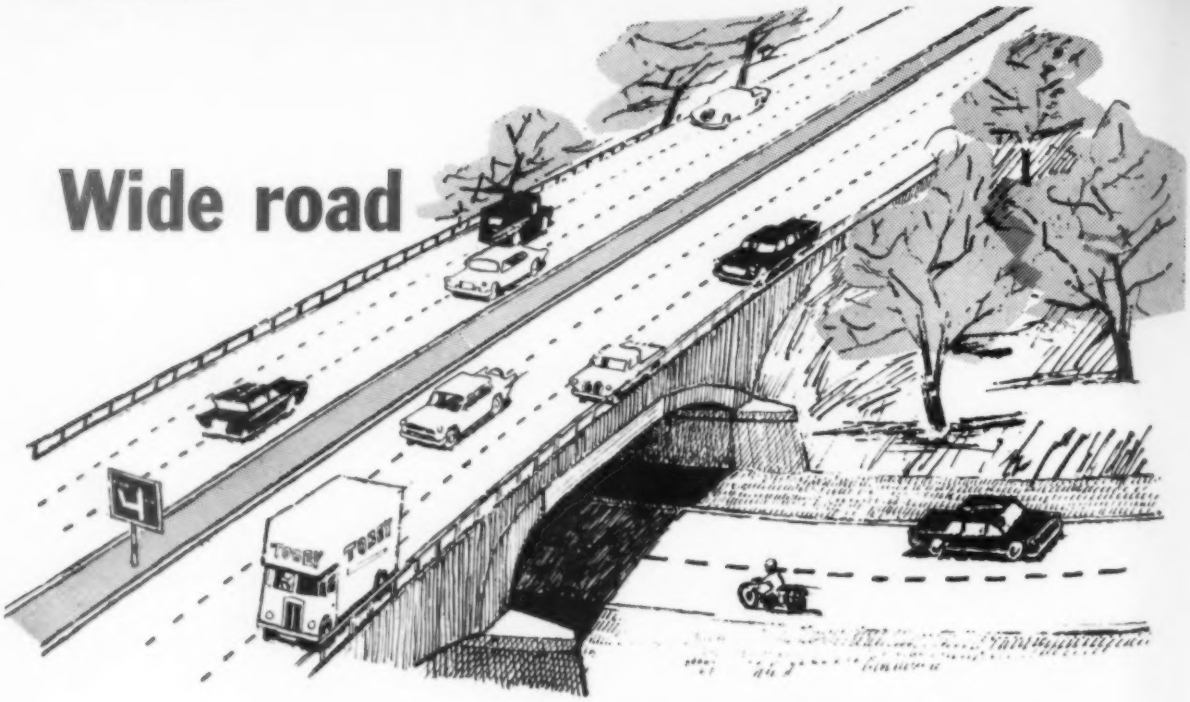

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CONTENTS

Editorial Opinion—Roads Progress 403

Topics of the Month 405

FEATURES

Effect of the M1 on Journey Time and Fuel Consumption . . . 406
R. F. F. Dawson

American Report—Experimental Case Studies of Traffic Accidents—(2) Methods 409

Motor Show Parking Quiz 412
B. D. Hankin

Traffic Intersections—(3) City Main Streets 415
Dr.-Ing. Max-Erich Feuchtinger

DEVELOPMENTS ILLUSTRATED 418

Profile—Brigadier R. F. E. Stoney, C.B.E., O.B.E. 420

Institution of Municipal Engineers Conference—Planning for Traffic . 421

—Road Traffic in the Counties . . . 422
James Drake and R. A. Kidd

Road Research 1960 424

Washington Conference—Design and Operation of Rural Freeways . 428
Charles M. Noble

—Freeway Operation 431
K. Vaughan-Birch

Book Review—Geometric Design of Modern Highways . . . 432

Lighting Section—Association of Public Lighting Engineers Conference . 433

Rubber in Roads 439

Industrial News and Information 443

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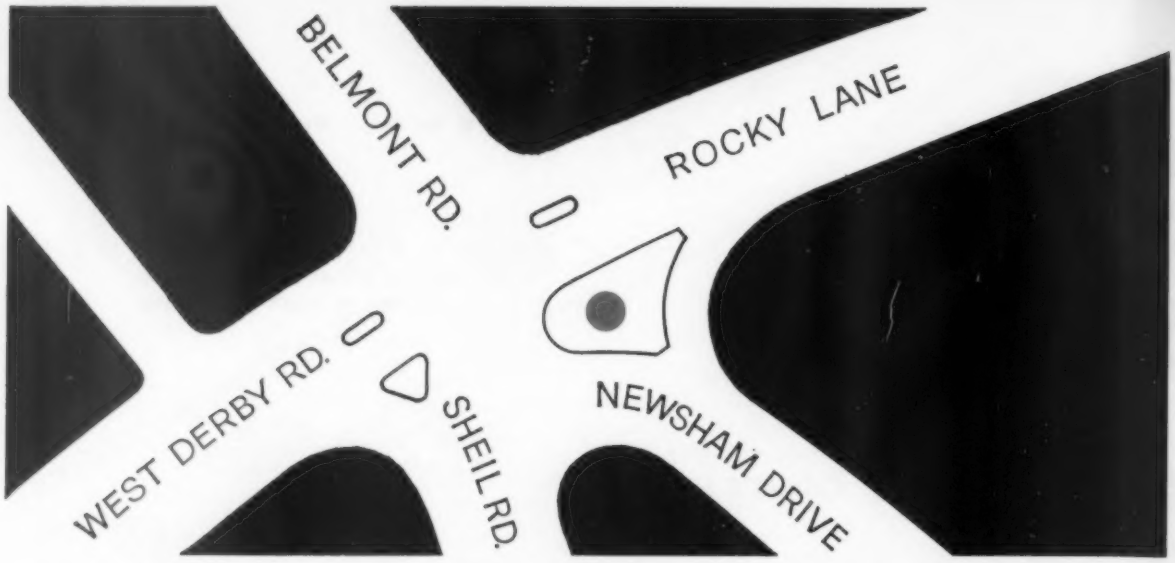

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ROADS PROGRESS

THE last two months have produced much new data on the great increase in vehicles and traffic and of the inadequacy of the roads programme to meet future anticipated growth. In his annual report, Sir William Glanville, Director of the Roads Research Laboratory, predicts a growth of 150 per cent in vehicles during the next 20 years. This is probably far more realistic than previous estimates on which, until recently, the Ministry recommended future planning should be based: in 1950 the volume to be obtained in 20 years was taken as an excess of 75 per cent over the 1938 census and in 1956 at 75 per cent over 1954 volumes. The first was reached in seven years and, since traffic is increasing at approximately eight per cent a year, the latter may well be next year, and not by 1974 as anticipated. While it may not have been possible to estimate accurately the size of the increase, the extent of the underestimate means that the roads programme and design capacity bear no relation to need. This was brought out strongly at the Institution of Municipal Engineers' Conference on 'Planning for Traffic', a report on which appears in later pages. Particularly convincing were the estimates given by the County Surveyors of Lancashire and Nottinghamshire of the likely overloading of roads in those counties on various assumptions regarding future road work and of the expenditure necessary to avoid it. Christopher Brunner interpreted their figures to indicate that to get to grips with the magnitude of the problem at least a doubling of present expenditure was necessary. Of this there appears little likelihood, both because the recently announced programme provides for an expenditure for £607 millions only in the period ending 1966-67 which represents little if any increase over the present level.

In a foreword to 'Roads for Britain', Mr. Marples states that the publication shows how every aspect is being tackled right from the best use of existing streets to the long-term planning of cities so that we can live with the motor car. He concludes 'One thing is certain—we shall press on and press on fast'. But the 'Story of Planning and Achievement', by which the Central Conservative Office describes its publication, far from bears this out. True, motorways are to increase from 148 to 275 miles by the summer of 1963, but that is pitiful beside the Federal Government of Germany's current plans for 2,521 miles of autobahn by 1966. Additional to the motorways there are only 778 miles of dual carriageways in the whole of Great Britain out of nearly 100,000 of classified roads. With greater authority and more responsibility the Ministry's own annual report, published last month, accepts the need for an overhaul of the main long-distance routes and the relief of urban congestion and describes without undue embellishment developments during 1960-61. However, those who are most aware of the needs—the municipal engineers—are sceptical of even the present programme being carried through. In the paper already referred to, it was pointed out that the highway authorities at government request submitted two programmes for 1955-56 to 1959-60 and 1962-66 but their preparation, it was alleged, was largely a waste of time because the first came to nought and the second would produce no noticeable improvement.

If the problem is to be seriously tackled, the roads programme must be drawn in relation to the growth of traffic and the authorized level of expenditure must be adequate to fulfil it. It must be fixed for a number of years ahead and adhered to. Although the local authorities should be given more scope in the choice of schemes, so that they can plan in the long-term for the whole of their area, the programme must be planned as a whole with a dovetailing of rural and urban construction and improvement. The motorway programme has been fully justified by results both as regards saving in time, and wear and tear—evidence of which is given in an article on the M1 in this issue. But provision must be made for distribution of the generated traffic in the urban areas for which it is generally destined. Development of the urban roads and traffic networks as part of urban renewal calls not only for far more expenditure than is at present contemplated but for new and imaginative schemes, as envisaged in his paper by the chief engineer of the London County Council, who foresaw urban motorways in tunnels. The urban problem is not being tackled with sufficient urgency and is further held back by slow procedure.

Although traffic engineering can help materially, the traffic engineer can work only on existing roads and the limit is narrow within which their capacity can be raised. The Conference on 'Planning for Traffic' was valuable in that it drew attention to the need for roads and traffic planning by revealing on the one hand the deficiencies in planning, the inadequacy of the roads programme, and the insufficiency of expenditure and, on the other, to the need for forward programming and continuity, and for standards adequate to meet future traffic volumes. The wishes and capability of those responsible for meeting the demands on roads and traffic management made by growing motorization were also demonstrated, as was the full sense of responsibility which was felt for meeting them speedily.

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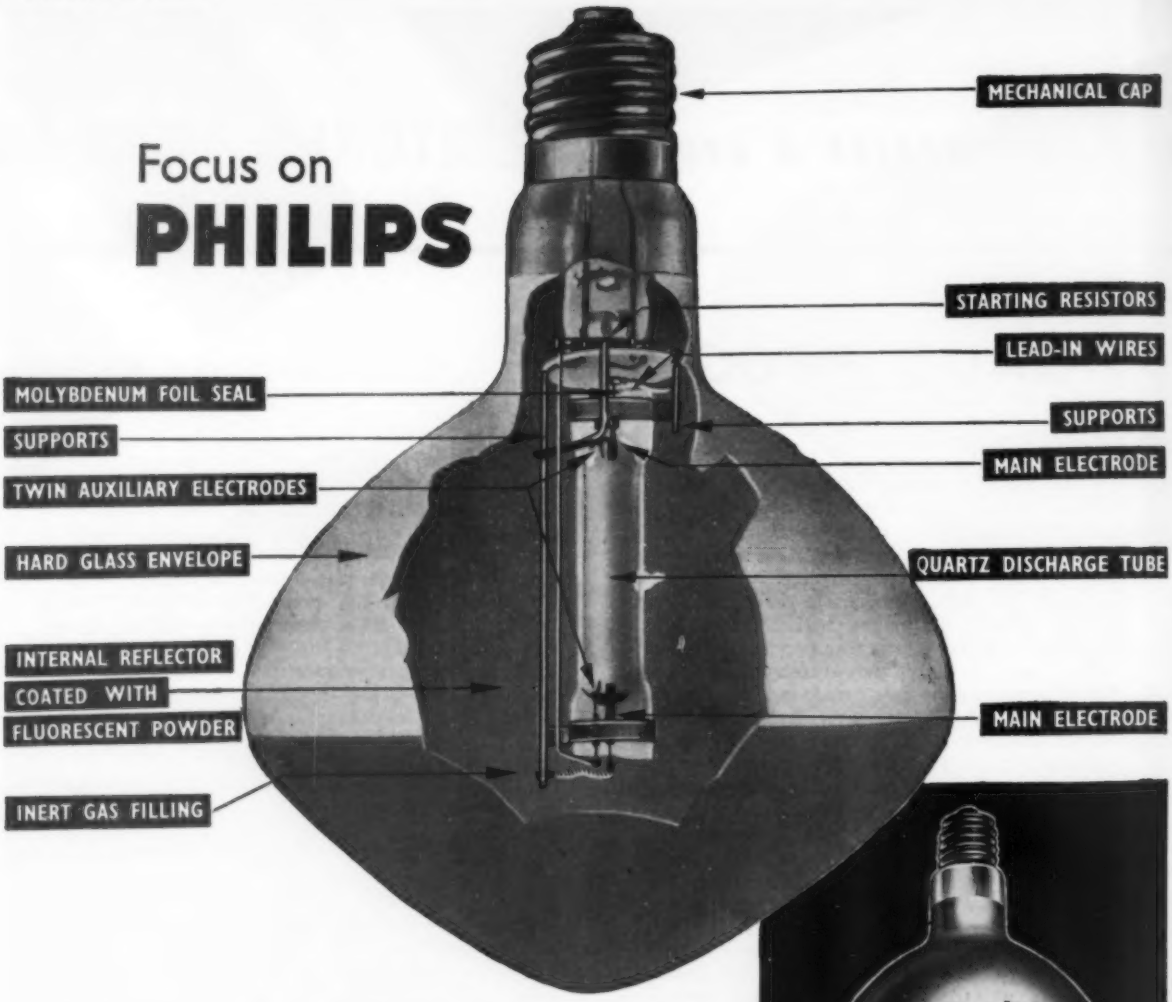

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Topics of the Month . . .

THE contribution traffic engineering has to make to improving the speed and flow of traffic is being convincingly demonstrated in Central London where, despite increased traffic volume, the speed of traffic has gone up for the first time in nine years. Year by year surveys by the Road Research Laboratory have revealed a decrease in speed corresponding to the increase in traffic, two per cent each year between 1952 and 1960. Recently, the London Traffic Management Unit of the Ministry of Transport conducted a survey which showed that on 40 miles of main streets, journey speeds were about nine per cent higher compared with a four per cent increase in traffic. The present average speed is about 10.7 miles per hour. Dr. Charlesworth is to be congratulated on this improvement, which is largely due to initiation of traffic engineering measures during recent months and which the Ministry, local authorities, London Transport and the police have co-operated in applying. The schemes have not involved any major construction or great expenditure, but constitute common sense restrictions on parking and loading, and waiting at or near intersections; on prohibition of right-hand turns; one-way working on the large scale, as in the Tottenham Court Road-Gower Street area; channelization of traffic at major intersections and rephasing of traffic signals. The short-sightedness of those affected parties who in the first place objected to such restrictions is shown up by this achievement and it is to be hoped that the improvement in traffic flow will forestall repetition of unreasonable objection and enable further measures which are contemplated to come into operation more speedily and to be effectively enforced.

Basic Road Statistics

THE British Road Federation's annual compilation of statistics of roads and vehicles, traffic and accidents, has become a standard work and each year throws new light on the exceptional size and nature of Britain's road and traffic problem. The 1961 edition shows Britain still to have the greatest density on its roads with 33.2 motor vehicles a mile. The figure for the United States is 21. Motor cycles and similar vehicles are excluded and their inclusion would bring the figure to 46.5. According to the British Road Federation, this means there is one vehicle for every 38 yards of road, which is frightening, and imagination boggles at what would happen were all on the roads at once. With so great a density, it is hardly surprising that road accidents continue to rise, and last year increased at the same rate as traffic volume—nine per cent. Casualties in 1960 totalled 347,551, of which 6,970 were fatalities and 84,443 serious injuries while the estimated cost to the community of road accidents was £229 million. The most effective contribution to a reduction of accidents would come from new construction and improvement and higher standards, as experience of motorways proves. As pointed out in the annual report on Road Accidents issued by the Ministry of Transport, during the first year of operation on the M1, the casualty rate per vehicle mile travelled was about half the rate on other roads without a speed limit, although, where accidents occurred, they tended to be more severe. Better roads are likely to be more fruitful in reducing accidents than the penalization of motorists involved in accidents, which was advocated at the Conservative Party Conference, and to some extent endorsed by Mr. Marples, who apparently still favours the abortive road traffic bill introduced in the last parliamentary session and to be reintroduced in the current one. He has reaffirmed that any person with three endorsements on his driving licence would be automatically suspended and disqualified for six months for a further offence. For minor offences this was considered unreasonable when the bill was previously discussed and hope that the Minister would have second thoughts was apparently in vain. Penalties sufficiently severe to deter dangerous driving are, of course, highly desirable, but where restrictions and penalties are unreasonable the motorist's co-operation cannot be expected.

Code of Lighting Practice

THE draft revision of the British Standard Code of Practice on Street Lighting, which was discussed at the Association of Public Lighting Engineers' Conference last month, constitutes a considerable advance on previous standards and in view of the convincing evidence that adequate street lighting reduces accidents, greater consideration needs to be given to the lighting of traffic routes. With the present comparatively low standard, one in three accidents occur at night, although traffic volume is proportionately far less. The new Code aims to meet changes in road conditions since 1936 and it is therefore essential that the standards proposed should be speedily accepted. The effect of the Ministry's recommendations, however strongly set forth, must have a limited impact, because of the anomalous position in regard to grants for lighting as compared with those for road works. Only for trunk road lighting is there a direct Ministry grant and then it is only 50 per cent; none is payable for lighting of classified roads. The report of the Consultative Committee on the Lighting of Traffic Routes within the London Conurbation strengthens the case for better lighting with its recommendations for complete uniformity, avoidance of abrupt changes in brilliance in street lighting, for the adoption of the highest standard of lighting for heavy traffic routes and their continuous lighting throughout the night. The Minister now has before him so much evidence that good lighting contributes to road safety that he has no excuse for further procrastination or parsimony.

Photo by Aerofilms.

EFFECT OF THE M1 on Journey Time and Fuel Consumption

by R. F. F. Dawson, B.A., *Road Research Laboratory*

THIS article reports the results of some observations, part of a series being carried out by the Road Research Laboratory, to measure the effects on traffic of the building of the London-Birmingham motorway, the main section of which was opened on November 2, 1959. The aim of the observations, which were carried out shortly before and shortly after the motorway was opened, was to determine the changes in fuel consumption and journey time of private cars and of commercial vehicles that would result from the use of the motorway. The effect of the motorway on traffic which transferred to the motorway and on that which continued to use the old routes were both examined.

Method

Before the motorway was opened a medium-sized car, a large saloon car, a diesel lorry and a petrol lorry were driven by different drivers in both directions along the A5/A45 route between St. Albans and Dunchurch. After the opening of the motorway runs were again made on this route and on the motorway.

For comparison, and to estimate the fuel consumption on the motorway over a range of speeds, the fuel consumption of the same vehicle was measured on the proving ground of the Motor Industry Research Association.

Recordings

Fuel consumption was measured by means of the M.G.A. Petrometa[1] which consists of a meter which passes the fuel and a recorder which indicates, by means of an electric counter, the units of fuel passed by the meter. The Petrometa can measure the fuel flow from the pump to the carburettor in units of two thousandths of a gallon.

All journey times were recorded by stopwatch.

An observer in the vehicle noted the number of times the driver applied the brakes and, in order to measure the number of clutch applications, the number of gear changes and stops.

Routes

All journeys commenced at the roundabout at the Park Street terminal of the motorway which is at the intersection of A5, A405 and M10 just south of St. Albans, and then continued either along the motorway (M10, M1, M45) or on the ordinary road A5 and A45 to the Dunchurch terminal, which is at the junction of A45 and M45. The distance of a round trip was 130.0 miles by the motorway and 123.6 miles by A5/A45.

Vehicles

The vehicles used in the experiment were a large 6-cylinder saloon car, a medium-sized 4-cylinder saloon car, and two 5-ton tipper lorries, one driven by petrol and the other by diesel fuel. There was no small car available to which the Petrometa could be fitted. Some runs were made with the lorries empty and others with a full load of approximately 5 tons.

Tyre pressures and engine settings were kept as constant as possible and the same grades of lubricants, petrol (premier grade) and diesel fuel were used throughout the experiment. Details of the vehicles are given in Table I.

Number of runs

Each car made six runs in each direction on the A5/A45 route in October, 1959 before the motorway was opened, and on the motorway after the opening. Two runs were also made by each car on the A5/A45 route in November, 1959, on the same days as runs were made on the motorway.

Each lorry made two runs loaded and two runs empty on the A5/A45 route in October, 1959, before the motorway was opened, and on the motorway after the opening. In addition, each lorry made one loaded run on the A5/A45 after the motorway opening. The 'after' runs by the petrol lorry were made in November, 1959, but those by the diesel lorry were carried out in April, 1960.

All runs were made on week-days and in daylight.

Drivers

The private cars were driven by three drivers, each one driving each car twice both before and after the opening of the motorway. The drivers were members of the Laboratory staff, two being professional drivers and one a member of the scientific staff.

TABLE I
Details of vehicles used

Detail	*Medium car*	*Large car*	*Petrol lorry*	*Diesel lorry*
Year of manufacture	1955	1954	1953	1956
Body and type	Saloon	Saloon	5-ton tipper	5-ton tipper
Approx. mileage	51,000	19,000	28,000	26,000
Engine capacity (c.c.)	1,390	2,262	3,622	4,728
Maximum power (b.h.p.)	43 at 4,400 r.p.m.	68 at 4,000 r.p.m.	85 at 3,500 r.p.m.	83 at 2,400 r.p.m.
No. of cylinders	4	6	8	6
Compression ratio	7.0:1	6.8:1	6.15:1	16.5:1
No. of gears	4	3	4	4
Fuel	petrol	petrol	petrol	diesel
Weight unladen	—	—	2 ton 19 cwt.	3 ton 3 cwt.

Photo by Aerofilms.

The lorries were driven by two professional drivers from the Laboratory staff, each driving each lorry once loaded and once empty both before and after the opening of the motorway.

The instruction given to the drivers was that they should drive normally and choose their own speeds.

Comparison of runs on M1 and A5/45

A summary of the results obtained is given in Table II.

After the opening of the motorway the time for cars on the old route decreased by 20 to 25 minutes with no significant change in the amount of petrol consumed. By using the motorway the cars saved 75 to 80 minutes in the round trip although the fuel consumed increased by 0.9 gallons.

By transferring to the motorway the petrol lorry saved 50 minutes and about 2 gallons per round trip when loaded and 30 minutes and 1.2 gallons when empty (the extra 6½ miles on the motorway could be expected to use about an extra 0.5 gallons).

There were larger time savings with the diesel lorry than with the petrol lorry (though the differences in time saving on the old route after the motorway was opened are based on only one run by each vehicle); with the diesel lorry, however, there was a small increase in fuel consumption which would be largely accounted for by the increased distance, the rate of consumption for the loaded lorry being virtually unchanged.

It is interesting to compare the results of this experiment with those of a test carried out by *The*

TABLE II

Average journey time, speed and fuel consumption of vehicles before and after motorway opening on journeys between Park Street and Dunchurch

Vehicle	*Load*	*Before*		*After*			
		A5/A45 Distance per round trip—123.6 *miles*		*A5/A45*		*Motorway* Distance per round trip—130.0 miles	
		TIME (minutes per round trip)	*FUEL—gal. per round trip*	*TIME (minutes per round trip)*	*FUEL—gal. per round trip*	*TIME (minutes per round trip)*	*FUEL—gal. per round trip*
4-cylinder saloon car (medium)	—	216 (34.3)*	3.5	194 (38.2)	3.6	135 (57.7)	4.4
6-cylinder saloon car (large)	—	202 (36.7)	5.1	176 (42.2)	5.0	128 (60.8)	6.0
5-ton petrol lorry	Loaded	286 (26.0)	13.5	277 (26.7)	13.7	238 (32.7)	11.4
	Empty	256 (28.9)	9.5			228 (34.2)	8.3
5-ton diesel lorry	Loaded	281 (26.4)	7.3	249 (29.8)	8.1	219 (35.7)	7.7
	Empty	246 (30.2)	6.1			207 (37.8)	6.8

**Figures in brackets are the mean speed in mile/h.*

Motor and described in the issue of November 11, 1959[2]. The test consisted of one round trip along A5/A45 before the motorway was opened, the results of which were compared with one round trip on the motorway a few days after the opening. The car used was an Austin A.50 of 1½ litres which is comparable to the medium-sized car used in this experiment. The use of the motorway resulted in a saving of 60 minutes and a negligible increase in petrol consumption of 0.08 gallons. This is a smaller time saving and a much smaller increase in petrol consumption than was found in the Laboratory's experiment and is probably attributable to the comparatively high speed of 39.5 mile/h. achieved by the A.50 and the consequently high petrol consumption on the 'before' run.

Estimated fuel consumption

By comparing the fuel consumption on the motorway with the results obtained with private cars on the M.I.R.A. proving ground it is possible to estimate the consumption per round trip on the motorway at speeds of 50, 55, 60 and 65 mile/h. These estimates are given in Table III, which repeats the average results achieved on the A5/A45 route.

TABLE III

Time taken and estimated fuel consumption per round trip at various speeds on the motorway compared with average results on the A5/A45 route

	Speed (mile/h)	*Time taken (minutes)*		*Fuel used (gallons)*	
		Medium car	*Large car*	*Medium car*	*Large car*
Estimated results on the motorway	50	156		3.8	5.1
	55	142		4.2	5.5
	60	130		4.6	5.9
	65	120		4.9	6.3
Average results on A5/A45	Before motorway opened	216	202	3.5	5.1
	After motorway opened	194	176	3.6	5.0

Similarly it is possible to calculate at what speeds on the motorway the amount of petrol used by cars would be the same as the average of the runs on A5/A45 before and after the motorway was opened. These speeds and resultant time savings are given in Table IV.

TABLE IV

Speed on motorway to use same quantity of petrol as on A5/A45, before and after motorway was opened, and resultant time savings

Comparison with conditions on A5/A45	*Car*	*Speed on motorway (mile/h)*	*Time saved by using motorway (minutes)*
Before motorway was opened	Medium	46.1	47
	Large	50.4	47
After motorway was opened	Medium	47.7	30
	Large	49.8	19

Brake and clutch applications

A comparison of the number of applications of the brake and clutch on the motorway and on the A5/A45 route both before and after the opening of the motorway are given in Table V together with the average traffic flows. As there was no significant difference between the number of gear changes on the large car and on the medium-sized car the results for both cars have been combined.

For the cars, brake and clutch applications and stops were reduced to two-thirds of the pre-motorway frequency on the old road and virtually were eliminated on the motorway. On the round trip of the motorway on average there was less than one application of brake and clutch, excluding the braking required to slow down before leaving the motorway.

In an earlier experiment carried out by the Road Research Laboratory, the brake and clutch applications were measured automatically between St. Albans and Weedon. Over the common route, the average number of applications of the clutch was similar—88 compared with 94; the number of brake applications, however, was considerably greater in the earlier experiment—88 as compared with 59. It is

(*Concluded on page* 411)

Experimental Case Studies of TRAFFIC ACCIDENTS

2. Methods

In the first of two articles under this title, it was explained how the Project Director of the investigation, J. Stannard Baker and his committee of scientists from Northwestern University, Illinois, U.S.A., conceived and planned the study on which these two articles are based. This, the second, is on the methods employed in carrying out the investigation and includes details of the type of information and data collected.

IT had been decided at the beginning of the study that certain criteria should be established (Table I), on which the decision of whether or not to investigate a particular accident was to be taken, and certain hours of the day or night were selected for the major portion of the study. A member of the team, or an associate, was on call by telephone throughout all the hours selected for study. This person, as his first duty during the period in which he was working, informed the police of the team's readiness to receive notification of accidents. The police in turn were instructed to pass on any information sent by their patrols which might interest the investigators. (Radio wavelengths used by patrols were monitored in later stages of the Study to make certain that all relevant notifications were being made). When the team were told about an accident the following procedure was followed:

(*a*) The team drove promptly to the scene of the accident and determined from the previously established criteria whether or not that accident should be investigated.
(*b*) The police informed the research unit that citations, if any, were to be made and whether or not they were willing to waive them.
(*c*) The police completed their own investigation and then introduced the team to those involved in the accident, to whom the team explained the Study and requested their co-operation. If the people concerned had already left the scene they were usually contacted by letter.
(*d*) If the necessary co-operation was obtained, the post-accident interview was made.
(*e*) Once co-operation was obtained, the engineer began his examination, which included the vehicle or vehicles involved, photographing the site, noting damage, debris and relevant aspects of the location. If the vehicle had already been removed, the engineer went as soon as possible to where it had been taken.

TABLE I
Criteria for the Rejection of Accidents

Criterion	*Accidents Rejected*
Damage negligible[1]	35
Commercial vehicles involved[2]	18
Research unit arrived after participants had left	7
Police investigators not briefed on procedure	6
Public service vehicles involved	4
Hit-and-run accidents	4
Other[3]	13
Total accidents	87

[1]*Criterion abandoned in May* 1959 *after case No.* 110.
[2]*The local chapter of the Teamsters Union would not give permission to have their members participate in the accident study. Because of this situation, no attempt was made to secure co-operation of management of local commercial fleets.*
[3]*Includes accidents in which an emergency vehicle was involved, in which participants resided more than* 100 *miles from the Traffic Institute, and accident calls that turned out not to be motor-vehicle traffic accidents.*

A participant describing a phase of the accident during the post-accident interview.

The procedure described was that followed in the third phase of the Study, from September 1959 to February 1960, by which time many accidents had been investigated and it was desirable to select those which would make the overall study of accidents in the Evanston area most representative.

The Post-Accident Interview

During the third phase of the Study a brief interview was carried out at the scene of the accident and a further, far more elaborate one was conducted in a specially converted and equipped motor bus, usually parked outside the residence of the person involved. The following preparations were made for each interview:

(1) Colour slides of the accident and locale were selected for showing.
(2) A scale map was prepared.
(3) Model cars were made available for the reconstruction of the accident by the person interviewed.
(4) The equipment—tape recorder, ortho-rater and medical instruments—were made ready.

The first part of the interview was conducted by the engineer, who directed the emphasis towards determining if the driver was aware of anything that might have been wrong with his vehicle. At the conclusion of this part of the interview, the engineer drove the vehicle in question, if possible, to the garage of the project mechanic. A detailed inspection was made while the physician and sociologist continued the interview. The vehicle was returned at the conclusion.

The sociologist, or more accurately the 'behavioural scientist', who conducted the second stage of the investigation used his skills as an interviewer to elicit information relating to events leading up to the accident and the driver's reaction to it. Driving characteristics, driving experience, events preceding the incident, and trip plan and opinions regarding the accident were some of the subjects examined. Much was recorded on tape. In the last phase of the Study, several psychological tests, modified for this special application, were employed to explore further the participant's attitude to driving. However, because they were only used on a small sample no definite conclusions can be drawn, but this field might well reward further investigation.

The third part of the interview was conducted by the physician. A comprehensive physical examination was made and a medical history obtained. Any injuries which may have resulted from the accident were carefully observed and recorded.

Final Case Report

The research team often returned to the site of the accident after the interview had been completed. This enabled them to take a second look at stable features of the locale after much additional information had been gathered. The details collected were next recorded on specially designed forms and when these had been studied the team arrived jointly at a consolidated summary.

A complete case history is too lengthy to be reproduced here, but details of the type of information and data sought, as reported in one complete case, are given below.

In the example chosen, which concerns a minor collision with no personal injury, separate forms or sheets were used to record the details regarding each individual vehicle and driver. These records included the following reports:

(1) *General information:* This included date, time, place, weather conditions, light reading, wind velocity, temperature, number of vehicles involved and the injuries or damage sustained. A map showing every possible relevant detail is attached and information given as to what other data would be collected.
(2) *The road:* The fullest details were given and included the status of road (Local, Interstate, Trunk or Sideroad), the area through which it runs and the police department in whose area it lies. Measurements of each traffic lane were given, and the measurements and description of footpaths, kerbs, ditches, shoulders, guard rails, fences and buildings. The surface details included type of surface, age, colour, condition, whether wet or dry, and the cross-section and alignment; details of other cars parked, vision obstructions, and light readings.
(3) *Visibility:* This deals with traffic signs and signals, of which the legend, size, angle, location, height, colour, reflectorization and legibility were recorded.
(4) *Location:* The exact position and measurements of skidmarks and debris were recorded on this sheet, and a photograph of a drivers view of the location was attached.
(5) *The vehicle:* Details of one vehicle only were recorded, all participating vehicles and drivers having a separate full case report. The data included make, age, body, type, number of doors, wheelbase and net and gross weights; style and operation of all major controls such as gears, brakes and steering and type and condition of the tyres. The interior was then described regarding condition. Car contents on seats and floor and a full description of door catches, padding, radio, seat belts, etc. were entered.
(6) *Accessories:* A detailed examination of all accessories, lights, trafficators, mirrors and wipers was recorded along with measurements and angles of windscreen and rear window.
(7) *Mechanical condition:* This contains a report on the mechanical condition of the vehicle.

(8) *Damage:* A diagrammatic record of all damage to the vehicle.
(9) *Medical:* Medical details of the driver were reported. These covered age, sex, race, height, weight, injuries, alcohol intake, illness, medication, visual acuity and eye pathology, hearing, sensory and motor defects, reaction speeds and the significant findings.
(10) *Driver characteristics:* Full details were recorded regarding age, sex, marital status, nationality, place of birth, first full-time occupation, father's occupation, education, present occupation. This sheet also recorded religious preference, type of residence (value and length of occupancy) and a brief self-description.
(11) *Driving Experience:* Method of learning and driving record are given finishing with a self-assessment of ability; types of cars driven, when and for how long; activities and background immediately prior to the accident and during the previous few weeks.
(12) *Trip Details:* These are recorded and any events occurring on the particular trip concerned.
(15) *Driver's statement:* A statement was obtained from the driver regarding the accident and events leading up to it, his actions, distractions and reactions. A diagrammatic representation of the accident is attached, and a description of the driver and his behaviour at the scene.

Psychological Tests

Finally, psychological tests were tried in some cases. Two of these are the Personal Opinion Inventory (P.O.I.) and the Automotive Thematic Apperception Test (T.A.T.) These tests were developed and varied to attempt to make their application to accident factors more specialized. The P.O.I. is a pencil and paper test to ascertain direct attitude and self-opinion measurements. The T.A.T. was developed into a Driving Situations Test and used to seek clues from individuals' driving attitudes that might be factors in the accident.

Conclusion

Several approaches to analysing the data were made and, apart from direct conclusions that could be drawn on, the methods of working and attitudes of the scientific investigators—conclusions in themselves important and described in the first of these articles—the team was unquestionably able to analyse accidents for causes more fruitfully than had been done in the past. The analysis was much more comprehensive than could possibly be carried out by police without extensive training. However, the cost of such investigation, and the recognition that many scientists would not relish the job of collecting data over an extended period, suggest that this is not a practical method for studying the tens of thousands of cases necessary for the full-scale evaluation of almost 1,000 potential accident factors.

A sample of fewer than 100 cases constitutes no firm basis for evaluating the relative importance of so large a number of factors which are thought to contribute to accidents. However, these cases give some new insight into certain aspects of accidents; for example, the extreme importance of inference by drivers about what other road users will do, the difficulties faced by drivers in coping with competing hazards, and the slight deficiencies of the elements of the highway system which will be enough, in combination with other variables, to make the difference between incurring an accident or not.

EFFECT OF THE M1, *Concluded from page* 408

possible that some of this discrepancy can be ascribed to the different method used to record braking in the two tests. In the recent experiment in what appeared to be one braking operation to the observer, the driver might sometimes have applied and released the brake several times; and these would have been recorded separately by the apparatus used in the earlier experiment.

Since the opening of the motorway, the number of applications of brake and clutch by drivers of lorries has been very considerably reduced on the A5/A45 route and on the motorway clutch and brake applications have been virtually eliminated. Loaded lorries very occasionally have to change gear, usually on the northern run; lorries heavier than those used in this experiment might have to change gear more frequently.

ACKNOWLEDGMENTS

Thanks are due to Dr. A. Fogg, Director of the Motor Industry Research Association, for permission to carry out the runs on the track.

The work described in this article was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research. The article is published by permission of the Director of Road Research.

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[1] *Manufactured by M.G.A. Industries Ltd., Loughton, Essex.*
[2] *Motorway Calibration. MOTOR,* 1959, *116* (2999).

TABLE V

Average number of brake and clutch applications and stops per round trip

Vehicle	*Load*	*No. of runs*			*No. of applications of:*						*No. of stops*			*Average flow* (vehicles per day)*		
					Brake			*Clutch*								
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Private car	—	12	4	12	71	38	2	106	63	0·7	18	12	0	13700	5800	12300
Lorry	Loaded	4	2	4	92	31	0	144	93	4	14	15	0	13700	5750	13500
Lorry	Empty	4	—	2	52	—	0	123	—	0	23	—	0	13700	—	13500

**Measured at Stoney Stratford and at the nearest point to it on motorway.*

A Route A5/A45 before opening of motorway
B Route A5/A45 after opening of motorway
C Motorway

Fig. 1. One of the early visitors is assisted in marking his parking place by a member of the Quiz team.

MOTOR SHOW PARKING QUIZ

by B. D. Hankin, *B.Sc., (Eng.), A.M.I.E.E.*
London Traffic Management Unit

In co-operation with the Metropolitan Police, the Research Branch of the London Traffic Management Unit surveyed the effects on traffic and parking in West London during the 1960 Motor Show. The Methods used are here described and some of the results given. No attempt is made to summarize all the data obtained.

UNLESS careful plans are made in advance a large popular exhibition such as the London Earls Court Motor Show is a potential cause of considerable traffic chaos. Not only are those who try to visit the Show affected; considerable inconvenience is also possible to local residents and to others passing through who may have no special interest in the Show. Traffic planning for such a situation demands reasonably accurate estimates of the scale and interaction of the various factors and the effectiveness of measures that are taken to alleviate the difficulties.

Use of Research Operations Room

In a project of this type an attempt must be made to see and measure the problem broadly. A relatively large area may be involved and it is inevitable that simultaneous measurement may be needed on a number of different aspects which are varying in magnitude hour by hour and day by day. The author has found it useful in this and many previous situations to set up a research operations room in a building on the spot to act as a focal point for the organization, collection, first analysis and initial study of the research material. Maps, charts and graphs displayed the data in this case within hours of it being handed in by the observers. The use of a Research Operations Room can assist analysis and observer staff to live closely with the problem and can help them to obtain and communicate a better and more practical understanding of it in a shorter time.[1]

Traffic Volume

In order to measure any changes in the volume or pattern of traffic in the area, traffic counts were taken at eleven points. The points were chosen to intercept traffic on all major through routes passing within about one mile of Earls Court. Observers on motorcycles visited each point at hourly intervals counting the traffic for five minutes in each direction. In the interests of simplicity for this particular study the traffic was not classified, every motor vehicle being counted as one unit.

The results showed that there was an increase in the *overall traffic level* except at the evening peak hours. This increase was of the order of 10 per cent before 4 p.m. and 20 per cent after 7 p.m. Road Research Laboratory counters in other parts of

London showed no appreciable change except after 7 p.m. when there was an increase of about 10 per cent.

Journey Time

In order to measure any changes in the degree of traffic congestion in the Earls Court area during the period of the Motor Show, journey times were measured by observers in two cars traversing two routes through the area. The survey occupied five days before the Show and five corresponding days during the Show. On each day observations were confined to a six-hour period, either from 10 a.m. to 4 p.m. or from 4 p.m. to 10 p.m. In each half of the survey three days and two evenings were studied on corresponding days of the week. One route was north-south from Shepherds Bush Green to Chelsea Embankment and the other east-west to Charles House (near Olympia) via Hammersmith and the Cromwell Road to Hyde Park Corner.

Among the results was the interesting finding that the one-way working put in hand by the Metropolitan Police in the north-south direction across the whole area reduced northbound traffic times by 30 per cent in spite of the increased traffic. The other routes on the whole suffered increases in journey time but these would probably have been far greater if there had been no police diversions, traffic control, route signing, etc.

Means of travel

A survey was conducted inside the main hall in an attempt to find out the means by which people reached the Show. A senior member of the research team stationed himself at a series of points inside the main hall and stopped and questioned the tenth person to cross an imaginary line. This was to randomize the sample and the procedure was repeated to obtain as many people as possible at different times of the day. The proportions travelling by various methods certainly varies according to whether the day had an entrance fee of £1 or 5s. In this survey the questioning was confined to 5s. days which had a remarkable consistency between days and did not vary greatly with time of day. A total sample of about 400 people was questioned. The Motor Show Manager was understandably very doubtful whether he could allow his visitors to be questioned but he finally agreed provided the questioning was carried out by a very senior researcher. In the event none of those questioned raised any objections. Table I gives the results.

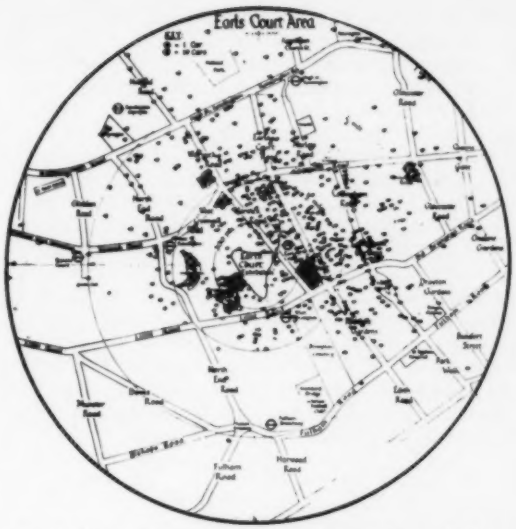

Fig. 2. Map of area around Earls Court with parked cars pinpointed.

TABLE I

Proportions travelling to the Show by different methods
(based on samples taken on 5s. days only)

Initial Method of Transport		*Completion of Journey*	*Individual* %	*Total* %
By Private Car	as Driver	On foot after parking within walking distance (two thirds mile)	11.5	27.5
	as Passenger		16.0	
	as Driver	By Train after parking at some intermediate point	5.5	16.0
		By Bus after parking at some intermediate point	.5	
		By Taxi after parking at some intermediate point	1.0	
	as Passenger	By Train after parking at some intermediate point	7.0	
		By Bus after parking at some intermediate point	nil	
		By Taxi after parking at some intermediate point	2.0	
By Train		Principally by subway from Earls Court Station	46.0	56.5
By Bus		Walk from nearest stop	2.5	
By Taxi		Dropped at entrance	3.0	
By Motor Coach		Dropped near entrance	4.0	
On Foot		—	1.0	
			Total	100.0

On two 5s. days a special quiz booth was set up in the principal entrance (Warwick Road). A team of attractive young ladies intercepted a sample of visitors as they came in and asked them if they were drivers of cars who had come with their vehicles to the Show. If so, they were asked to stick a pin in one of the two maps, each 3 ft. 6 in. in diameter to show where they had parked. (Fig. 1). One map indicated those within one mile radius and the second those falling outside this but within nine miles of the Exhibition. Changes were made in the colours of the pins to distinguish between exhibitors (who entered before 10 a.m.) and between the normal and cheap entry rate which changed at 5 p.m. Larger pins of the same colours indicated 10 units where overcrowding of pins made this necessary. The booth was made deliberately as striking and attractive as possible and the public quickly understood the idea and seemed very interested and co-operative.

Use of Streets and Car Parks

Observations were made in the streets before and during the Exhibition to show how cars were distributed at various times of the day. It was necessary to break the area down into sample areas at various radii and look at these in detail. Observers walked a pre-arranged route in selected streets counting the cars at hourly intervals. Special counts were also made at official car parks in the area and surveys arranged to determine the length of stay. There is a constant turnover of cars in both streets and car parks so that the number measured at a given moment is clearly much smaller than the total who park during the day. In addition to providing information on the increase in the number of cars parked in the area due to the Show these surveys included the following results.

(*a*) A doubling of the parking density within one-third of a mile during the Show.

(*b*) A noticeable increase in the parking density in the one-third to two-thirds mile area.

(*c*) A negligible increase in parking density during the Show beyond two-thirds of a mile.

(*d*) Cars parked for periods varying from half an hour to more than nine hours. The average for both streets and car parks was 4½ hours. (This average is, of course, a little misleading as it incorporates the effect of all day parkers, such as some exhibitors).

(*e*) The contribution made by the streets within two-thirds of a mile and all the car parks put together was about equal.

Overall Transport and Parking Situation

The data which were collected, together with visitor entry rates supplied by the Motor Show Manager, were used to build up the attached chart and table to describe the overall situation. They refer to a typical 5s. day with attendance of 41,000. The chart shows an obvious relationship between the cars and the people in the exhibition with noticeable peaks at 2 p.m. and 8 p.m. The maximum number of cars connected with the Motor Show within two thirds of a mile at any instant was about 3,000. Table II on page 417 is an estimate of how those in the hall at 2 p.m. came to the Show and where their cars were parked.

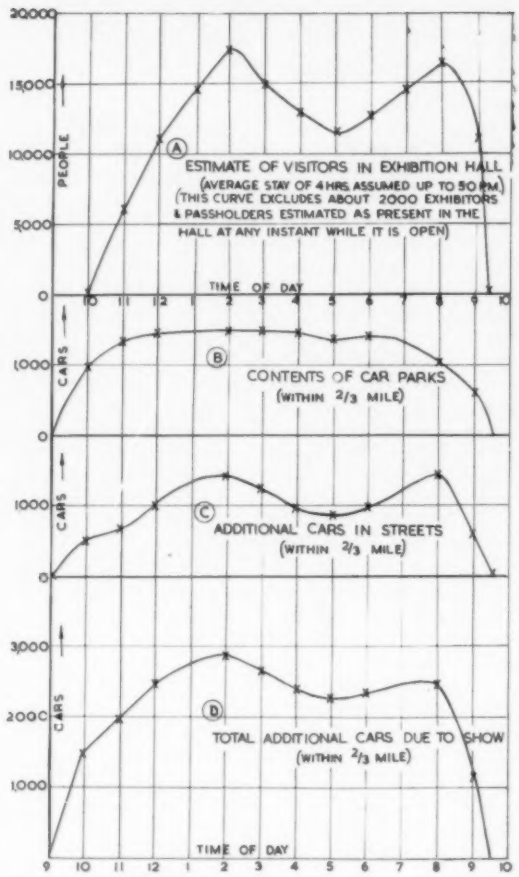

Fig. 3. Curves showing estimated relationship between numbers in exhibition hall and cars connected with show within two-thirds mile.

It is of interest to ask what happens when the number of visitors rises well above 41,000, e.g. on a Saturday, say 75,000. Further research is required on this point but there are some indications that the number of cars does *not* rise in the same proportion. It seems possible that when people expect very large crowds a greater proportion make up their minds to leave their cars behind.

(*Concluded on page* 417)

ACKNOWLEDGMENTS

Acknowledgment is made to the Manager of the Motor Show and others for their co-operation in this investigation. The paper is published by permission of the Ministry of Transport.

REFERENCE

[1]A detailed general account of this technique by the Author is given in the Operational Research Quarterly volume 11 No. 4 'Operations Room Technique in Operational Research'.

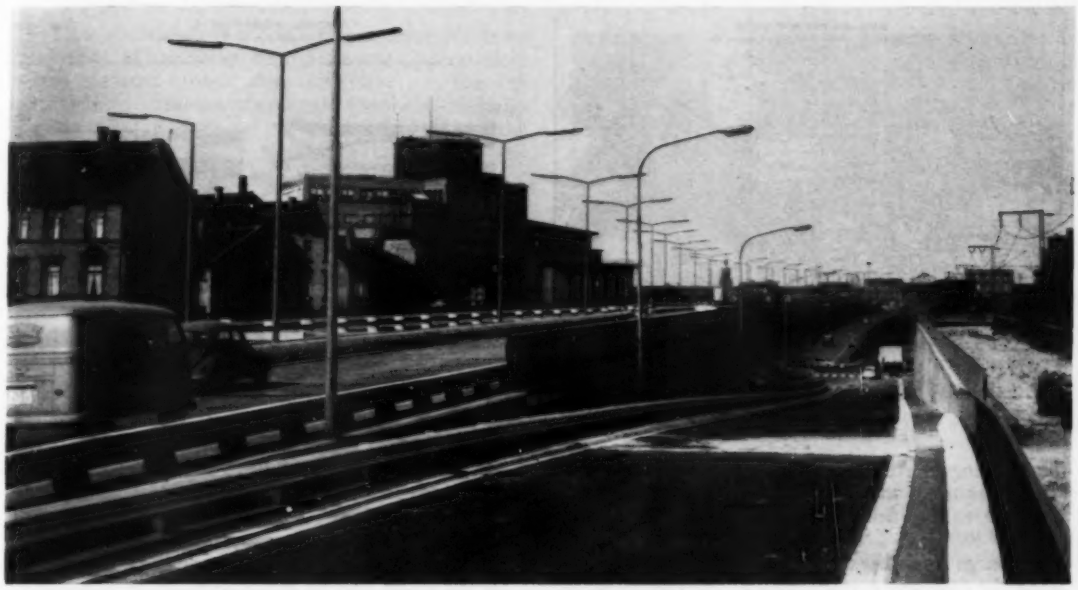

Fig 1. Ludwigshafen. Intersection of the elevated highway with a secondary road below, with which it is connected by ramp.

Traffic Intersections

Dr.-Ing. Max-Erich Feuchtinger

3. City Main Streets

This is the third article in a series of four containing extracts from the last published work of the late Dr.-Ing. Max-Erich Feuchtinger. They have been compiled, edited and translated by Arthur Henderson, Consulting Traffic Engineer.

THE tendency of city street traffic to concentrate in the city centre finds traffic not only precipitated into the heavily loaded main arteries leading to the city centre, but also in the heavy loading of the main intersections. Nearly every city regardless of its size exhibits one of a few 'hot spots' of traffic which embody a traffic crisis in its most concentrated form. It is obvious then how the highway construction engineer and the traffic engineer have to give special attention to the main street intersections, and aim to bring improvements and better traffic flow with all the techniques available.

Moreover, the principle remains here that there is no given solution to a traffic scheme in dealing with traffic problems, but that each case is different in practice and demands individual treatment. Only through exact traffic analysis, which must consider all traffic situations, can the traffic planner obtain the necessary indications concerning existing peculiarities and thereby suggestions as to the most expedient remedies to adopt. It is essential that the intersection should not be seen in isolation, but especially noted within the overall context of the neighbouring intersections and surrounding feeder streets. For there is no use in developing one intersection particularly highly when neither the feeder streets nor the neighbouring intersections are capable of carrying the corresponding capacity.

It is not possible to start from basic principles covering the design of main street intersections within the limits of the present work. We will limit ourselves to one planning example in Hamburg at

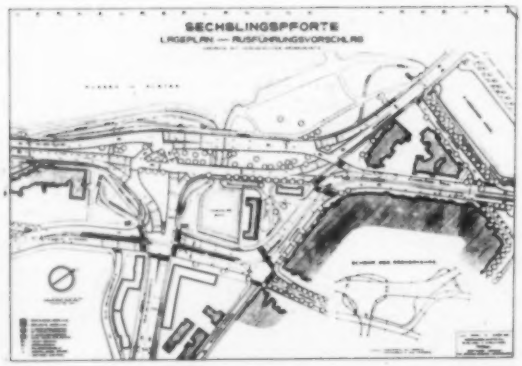

Fig. 2. Hamburg, Sechlingspforte: general development plan as adopted.

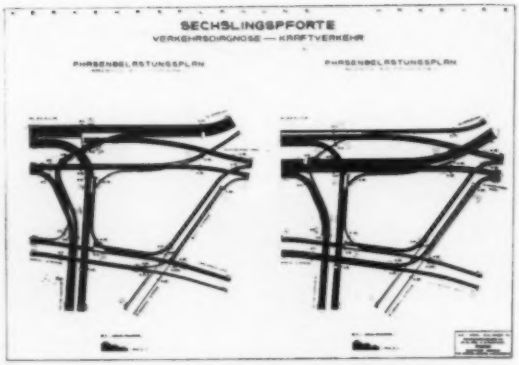

Fig. 3. Hamburg, Sechlingspforte: showing tidal-flow of traffic over the intersection at morning peak hour, left, and evening peak hour right.

the Sechlingspforte intersection where certain peculiarities require consideration concerning the commuting traffic as tidal flow influences on the traffic.

Hamburg: Sechlingspforte Intersection

With the increasing motorization, the mastering of the daily peak hour traffic of commuters becomes increasingly more critical. In the fully motorized United States, in the large cities the traffic streams between place of residence and place of work have been so heavily swollen that the principle of changing direction of one-way streets has already been used in large measure: in the mornings inward towards the city, and in the evening outwards from the city. A refined form of this principle is the occasional changing of lane direction according to the situation of the traffic at any specified time (Lake Shore Drive in Chicago, George Washington Bridge in New York).

In Europe the influence of 'tidal-traffic' prevailing in one direction is in general not so great that similar sized measures are customary. However, in the future design of city expressways—urban motorways—one will need to consider whether the arrangement of a fixed median strip would still be correct in all cases, or whether on occasions no divider or a movable one would be preferable.

Hamburg (1,815,000 inhabitants) is the first German city which has had a one-way street flow with directional change in use for some time. This is on a road between a highly motorized residential section of the city and the city centre along which there is located the important Sechlingspforte intersection, which was redesigned and constructed in 1956 (Fig. 2). In 1954 Max-Erich Feuchtinger was assigned by the construction authority to determine through a traffic survey to what extent the authority's preliminary design for the reconstruction of the intersection should be adjusted for the morning and evening peak traffic periods.

In the traffic calculations which were carried out for both peak traffic periods the results indicated certain recommendations for the refinement of the design to meet the morning peak traffic, flowing mainly towards the city, and the evening peak traffic, flowing outward from the city (Fig. 3). However, in view of the beautiful location of the intersection by the Alster Lake and the green open space, the changes could be executed only in part. The rebuilt intersection, in which a second level for cycle traffic has been used, functions flawlessly and deals with the heavy hourly variations in traffic flow without difficulty.

Urban Motorway Intersections

Urban Motorways free of crossings and buildings for exclusive use by motor vehicles in urban areas have become an indispensable part of modern town planning in America. In recent times we have also begun to adopt similar methods in European cities where the constantly increasing traffic problem demands radical measures[1]. In Germany, Berlin, Hamburg, Düsseldorf and Duisburg are among the cities which have accepted the consideration of urban motorways as a new form of highway and have constructed them.

The dovetailing of this type of highway, which is very demanding on space, with the existing body of the city presents a difficult task for traffic techniques as well as city construction. It demands that the planning engineer approaches his problem with much imagination, and that he does not assume that he can fulfil his task with a few standard types and sizes in regard to the design of alignment, cross-section, intersections and access points. Indeed, the varied aspects of intersection design make it particularly appropriate to project urban motorways into middle sized cities, as is shown in the following example[2].

An important prerequisite for the functioning of urban motorways is their faultless coupling with the city street network which must be expanded, and the installation of parking areas and garages to take care of the parked vehicles. If this is not attained then there is danger that the urban motorway will produce traffic bottlenecks instead of traffic relief.

Ludwigshafen: Elevated Urban Motorway

Urban Motorways should therefore not be considered only for large cities as solutions for traffic problems. Within the clever utilization of the local situation they may constitute the most fitting traffic solution in small cities or medium sized towns. Thus it has been possible, for example in Baden-Baden, to build a connector road from the Karlsruhe-Basel Autobahn as an urban motorway up to the edge of the Spa district. Similarly, in Ludwigshafen (160,000 inhabitants) the first portion of the urban motorway has been built in conjunction with the reconstruction of the Rhine Bridge.

This resulted from the fact that at three points on the edge of the inner city multi-level intersections with elevated streets were necessary: on the left bridgehead of the reconstructed Mannheim-Ludwigshafen City Bridge; on the left bridgehead of the planned North Bridge to Mannheim; and in the area of the so called 'Viaduct' to be rebuilt over the railway yards in front of Ludwigshafen Main Station. It was, therefore, suggested that these three intersections be constructed so that, through sections of elevated street there would be a complete U-shaped elevated street system around the centre of Ludwigshafen.

The elevated motorway system completely relieves the inner city from all through traffic. Thus the inner city can develop from the planning standpoint its business and cultural centre without having to contend with non-terminating traffic and traffic jams. In the main this improvement can be traced back to the individual development of intersections so that such an elevated street system appears to be even economically feasible for a middle sized urban area (Mannheim and Ludwigshafen together have a population of 400,000). (Figs. 1 and 4). In addition, detailed traffic calculations have brought proof that this system is practical also from the traffic viewpoint, since the Rhine Bridges can only be utilized to their full capacity if they have connecting arteries with similar capacity.

Finally, it should be added that shortly after the new elevated street system had been planned construction started, aided by the fact that from the very beginning the plans were divided into several construction sections. Along with the new Mannheim-Ludwigshafen City Bridge the southern part of the elevated street system was opened to traffic in September 1959.

Of particular note there is the so-called Pfalzbau intersection at the left of the bridgehead with three levels for street traffic. On the other hand, the intersection called the Viaduct, developed as a roundabout at one level with, however, removal of the trams, cycles, and pedestrians, must be viewed as the weakest part of the new traffic system. Only such a concession made it possible for a town of the size and economic status of Ludwigshafen to propose a realizable urban motorway plan. Moreover traffic calculations have proved that the capacity of the Viaduct intersection is adequate. (The roundabout mentioned here has since been altered.)

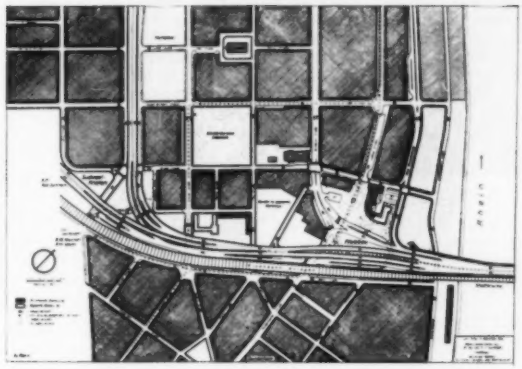

Fig. 4. Ludwigshafen, high level road: general development plan showing viaduct and interchanges.

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Parking Quiz *concluded from page 414.*

TABLE II

The Transport and Parking Situation at 2 p.m. peak

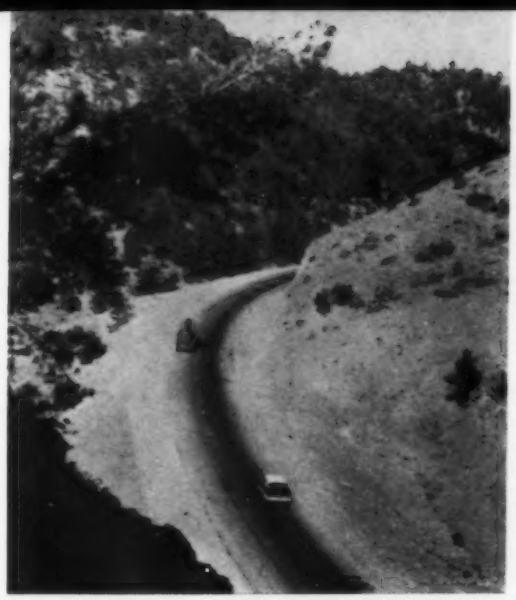
(The table has been built up by combining all the available data to show the problem in perspective. It must be regarded as approximate).

People in Exhibition Hall at 2 p.m. (Includes Exhibitors and Passholders)	*Means of Transport Used*	*Number of Cars used and parked at 2 p.m.*	*Parking location (with reference to Exhibition Hall)*
5,300	Car to within Walking distance	1,500	In car parks within two-thirds mile (Includes about 700 Exhibitors Cars)
		1,500	In the streets within two-thirds mile. (Includes a small number of Exhibitors Cars)
3,100	Car to intermediate point, then completing journey as follows: 2,400 people by train 100 people by bus 600 people by taxi	1,300	700 at two-thirds - 3 miles
			350 at 3 - 6 miles
			250 at over 6 miles
10,900	All the way by means other than car i.e.: 8,800 people by train 500 people by bus 600 people by taxi 800 people by coach 200 people on foot	Nil	Not applicable
19,300	As shown	4,300	As shown

Top: *The suggested right hand priority for traffic at roundabouts is being given a trial at Gant's Hill Roundabout at Ilford, Essex, where this sign has been erected for experimental purposes.* **Centre:** *An entry ramp on to the Hollywood Freeway in Los Angeles, U.S.A. at a four level intersection crowded with peak hour traffic.* **Bottom:** *Harbour Freeway, Los Angeles, showing the circular on ramp, a slip ramp and collector road. Details of interchange design are to be found on page 428.*

DEVELOPMENTS

(Photos: Department of Highways California)



(Photos: International Roads Federation)

Top: *State Highway 35 in Turkey as it runs through the arid mountains between Kizilcahaman and Gerede. It is designed for a maximum loading of 24 tons.* **Centre:** *A section of the recently opened Autostrada in Portugal. It runs from Lisbon to the National Stadium.* **Bottom:** *Road signing in the South of France. On the new Autoroute de l'Esterel the demarcation of traffic lanes and central reserve and place names incorporating paint reflectorized with Superwald TNC*

TS ILLUSTRATED

(Photo: Prismo Ltd.)

PROFILE

BRIGADIER R. F. E. STONEY

BRIGADIER Ralph Francis Ewart Stoney, C.B.E., O.B.E., Director General of the Royal Society of the Prevention of Accidents, RoSPA, is in outward appearance very much the military man.

The moustache, the upright bearing, the air of resolution and the alertness of his whole demeanour all add up to the generally accepted picture of the retired officer. But this is by no means the complete picture, and is an underestimation of a man of wide sympathies and interests.

Within minutes of meeting Brigadier Stoney one becomes aware of an immediate charm and warmth of character, projecting the atmosphere of the country gentleman, which is perhaps due in part to his Anglo-Irish parentage. Most certainly his volatility of mind and quick imagination, derives from his Celtic forebears. His father was an Army man from County Wicklow. However, his youth was not spent roaming the 'blue hills' near Dublin, he spent this formative period under the strict discipline of the naval colleges of Osborne and Dartmouth. Subsequently he transferred to the Royal Military College at Woolwich, known the world over as 'the Shop', graduating as an officer in the Royal Corps of Engineers—a most unusual background of dual naval and military training. He served in both World Wars, and while with the 82nd Division in Burma in World War II, was mentioned in despatches. After the war, in 1954, he was with Intelligence in the Middle East. In 1959 he retired and joined RoSPA as Director General.

To this second career, the Brigadier brought tenacity of purpose, absolute sincerity and enthusiasm. Questioned, as to why a trained man of war should turn to work directed at the saving of life, he explained:

> That is a misconception of the role of the professional service man. The whole basis of a regular officer's training, and the men under him, is designed to preserve life. Hours of small-arms drill and routine training, are needed in order to instill into each man an instinctive and correct way of handling weapons, either in an emergency or among the hazards of battle itself. Prevention of accidents is not so far removed from the basic tenets of the service man. A fully trained soldier, or sailor, will, it is expected, at all times take the right, as opposed to the wrong action, in order to avoid injury or loss of life. The right action should become axiomatic, automatic and instinctive. I wish that this could be the case with users of our roads, both pedestrians and drivers.

Elaborating this point further, he said:

> I am convinced that it is precisely this lack of 'know how' that is responsible for so many of the accidents on our roads, in people's homes and in the factories. This lack and above all—selfishness. Ignorance and selfishness are the two great enemies of accident prevention. It is plumb selfish to take risks involving others. No one has a right to take another person with them into the next world, and statistically our only yardstick of safety is death. In many instances knowledge of how to minimize risk also prevents injury or death. Just look at these statistics. They cannot be quoted often enough.

Brigadier Stoney produced a chart of road casualties in Gt. Britain for 1960, which has proved to be the worst peacetime year for deaths on the road since 1934. There were 271,787 accidents involving 433,747 vehicles of all kinds. 6,970 persons were killed including 747 children. 84,443 persons were seriously injured and 11,857 of these were children. 256,138 persons were slightly injured including 41,063 children. Of this total of 347,551 casualties during 1960, 53,667 included death or injury to children. This is an overall rise of 1,979 (or 3.8 per cent) in casualties to children and an increase of 67 deaths (or 9.9. per cent) over the previous year. Terrifying as the figures are, in terms of human misery and senseless waste of life, Brigadier Stoney said:

> We keep accident prevention work among children foremost among the Society's activities. Some decades ago, five children were killed every day on the roads.
>
> Today this figure has been reduced to two or just under two children a day. It is, however, not generally realized that over 8,000 people meet their deaths every year in the comparative safety of their own homes: 10 times this number, some 80,000, are seriously injured and a million and a quarter suffer minor injuries in domestic surroundings. These are higher figures than those for deaths and injuries on the roads.

Brigadier Stoney spoke of the invaluable voluntary help he received.

> Many sincere men and women in these fields do valuable work in making the public more conscious about accident prevention.
>
> Our materialistic society needs to be constantly reminded of why we are in this world at all. Christians should think all the time of their personal responsibility towards their fellow men. Road deaths have risen at the rate of about 400 a year, at this rate deaths will exceed 10,000 a year in the late sixties, and casualties will be more than half a million a year. I believe that we have one hope in this country of stemming this dreadful trend, and that is that people here are innately courteous. In this respect Great Britain compares favourably with the United States and Europe.

Brigadier Stoney is constantly drumming up new ideas and examining new techniques of safety generally and accident prevention on our roads. Particularly, he is concerned with children. He is a parent himself, although his daughter Heather is now a grown-up actress of twenty working in a repertory company. When he can he escapes with his wife for a holiday in Ireland, where he enjoys 'messing about in boats' and sailing.

Municipal Engineers Debate

PLANNING for TRAFFIC

THE difficulties of 'Planning for Traffic', the theme of the one-day Conference of the Institution of Municipal Engineers on October 5, was stressed both in the papers presented and by speakers from the floor, local government officials and elected representatives alike. Tortoise-like procedure, inadequate funds, lack of continuity and absence of overall transport planning were among the chief criticisms.

Thus James Drake and R. A. Kidd, County Surveyors of Lancashire and Nottinghamshire respectively, stated in their paper 'Planning for Road Traffic in the Counties':

> 'So far all the programmes which have been prepared have been largely a waste of time. They have resulted only in abortive effort on the part of the staffs of highway authorities and the generation of an even more acute sense of frustration. This sense of frustration must continue to prevail until in Government circles there is a realization of the enormity of the problem, a real assessment of the economics of the matter and the announcement of a realistic programme defining the amounts of money to be made available over a period of years with a view to effecting some real impression on the urgent and pressing problem of improving our more important roads to a satisfactory standard.'

Christopher Brunner, Chairman of the International Roads Federation, supported this, when he said that since, as they have assured us, the main obstacle is the lack of money, the Minister of Transport ought to urge upon the Chancellor the necessity for at least doubling the road programme immediately.

Need for National Plan

On planning, J. Rawlinson, Chief Engineer of the London County Council, speaking on 'London's Traffic Problem', said that the solution would be found by approaching the problem from the point of view of an overall plan for transport and not by taking piecemeal account of the need of each local authority or individual public transport service organization. He advocated the setting up of a powerful planning transportation committee to determine the best overall transport system for the country. He was supported by C. W. King, Chief Civil Engineer, British Railways Central Staff, in his paper 'Planning for Traffic' when he suggested that for road and rail co-ordination—which he strongly favoured—there should be a national plan and a national programme and a measure of national traffic regulation. S. G. Wardley, after describing the planning and execution of the town and traffic plan for Bradford, for which he is City Engineer, Surveyor and Town Planning Officer, stated that planning for both traffic and town development were inseparable and that Bradford had acted successfully on this precept.

John Hay, M.P., claimed that the Ministry of Transport, of which he is Parliamentary Secretary, was trying to achieve a co-ordinated policy:

> 'Our policy is to establish and maintain a situation in this country under which each form of transport is given the conditions under which it can make its optimum contribution. We are *not* planning in the sense of trying to control all forms of transport and dictate to the user. We believe the user should have a free choice of the transport facilities he wants.'

He added that, although the Ministry's responsibility towards the different forms of transport varied, the aim was always the same

> 'to allow each form of transport to play its proper part in developing our national life and fortune'.

Procedural Difficulties

On procedure, Mr. Rawlinson said that he was convinced qualified professional and technical staff was available to cope with a much larger programme for London provided the crux of the problem was solved which was that land and property would have to be acquired and cleared much more quickly than at present. After describing the lengthy procedure from a Compulsory Purchase Order to clearance, which took up to five years, he concluded:

> 'It may well be that in a democratic country like ours, any speeding up of the procedure for acquiring land and property is impossible on the grounds that it would cause undue hardship. It is evident that if the Government are anxious and determined to put into operation quickly special and urgent improvements in urban areas then steps will have to be taken to expedite the present long drawn out procedure for acquiring property.'

Mr. Rawlinson was supported by the Chairman of the L.C.C. Roads Committee, Richard Edmonds, who, speaking from the floor, said that it was not only the procedure which needed speeding up but quicker action and decision in the Ministry itself. He instanced cases where, after the '31 steps' had been surmounted, the Ministry of Transport had taken a year or more to reach a decision. Another speaker who strongly advocated speeding up procedure was Wilfrid Andrews, Chairman of the Roads Campaign Council, who saw no difficulty in it being streamlined.

Mr. Hay defended the present methods as the necessary concomitants of planning in a crowded democratic island, and tried to allay the criticism by stating:

> 'Many of you, I know, are critical of the time taken between stages, and Mr. Rawlinson in particular has some rather gloomy things to say in his paper about the difficulty of making quick progress with the acquisition of land for street improvements in London. But the statutory procedures which have been laid down by Parliament are specifically designed to safeguard the interests of the individual.
>
> 'The plain fact is that luck enters into the equation very substantially. If you are fortunate, things may go very smoothly, nobody will raise substantial or difficult objections, and you may keep up with your Statutory timetable without too much difficulty. But if you are unlucky; if individuals, or even—dare I say it?—Highway Authorities, put in objections, the timetable may slip substantially, and then everybody blames the Minister for dragging his feet! Anyhow, I think we have to go on working within the Statutory framework that Parliament has laid down until such time as Parliament, in its wisdom, says that things should be altered.'

Traffic Engineering

The Parliamentary Secretary had this to say of the use made of traffic engineering techniques which he considered to be particularly helpful in regard to short-term measures:

> 'These can be used to bring quick relief to congested areas, especially inside our towns. Traffic engineers help us, in fact, to make the best possible use of our existing roads and streets. Their measures have these advantages—that they can be introduced fairly quickly, and at a relatively low cost. The paper by Mr. Drake and Mr. Kidd mentions several of the methods which traffic engineers can use.
>
> 'We attach the greatest importance to traffic engineering methods as a source of immediate improvement of traffic conditions. The need for traffic engineers is, I know, fully appreciated by many local authorities, but there is certainly scope for more use to be made of their services in some areas. We should like to see a rapid increase in the numbers of traffic engineers and traffic engineering technicians being trained and employed in this country, and I do most earnestly beg you to consider how far you can go in this and to study the benefits already being obtained up and down the country by these methods.'

Extracts from the paper prepared by Mr. Drake and Mr. Kidd which are particularly relevant to traffic engineering follow overleaf.

ROAD TRAFFIC in the COUNTIES

by **James Drake,** *B.Sc., M.I.C.E., M.I.Mun.E., P.P.Inst.H.E., County Surveyor and Bridgemaster, Lancashire*

and **R. A. KIDD,** *C.B.E., B.Sc., M.I.C.E., M.I.Mun.E., M.T.P.I., County Surveyor and County Director of Planning, Nottinghamshire*

COMPETENT authorities have recently given facts relating to the present growth of traffic, and, based on these present trends, authoritative estimates have been made of future traffic intensities. Before proceeding to examine these estimates of future traffic, it is instructive to look back over the last 20 years or so and trace the growth of traffic which has already occurred and compare this with forecasts of anticipated traffic growth made during that time.

Although the 1950 and 1956 estimates of future traffic have already been proved to have been hopelessly inadequate, it is felt that, with the experience now gained with regard to traffic growths, the more recent official estimates will prove to be much more realistic and will allow for a future increase of 150 per cent over the next 20 years. This estimate will provide for approximately 0.4 vehicles per head of population (i.e. 2.5 persons per vehicle) and cannot be regarded as excessive as such a ratio already applies in regions of the United States with similar population densities to those existing in this country.

Magnitude of the Problem

It must be acknowledged that the present highway system leaves very much to be desired and this results largely from the failure in the past to allocate funds for roadworks bearing any realistic relationship to the nature of the task in hand. Despite frequent warnings from authoritative bodies and individuals fully alive to the situation which was developing and despite the present somewhat accelerated road programme, the country is still faced with a formidable backlog of work.

The following recommendations for carriageway capacities have recently been published in Ministry of Transport Memorandum No. 780 and are accepted as a sound basis of design:

Two-lane carriageway (24 ft.)—6,000 p.c.u./day.
Three-lane carriageway (33 ft.)—11,000 p.c.u./day.
Dual carriageways (2 x 24 ft.)—25,000 p.c.u./day.
Dual carriageways (2 x 36 ft.)—over 25,000 p.c.u./day.

Using these capacities as a yardstick an analysis has been made of the traffic situation in the counties of Lancashire and Nottinghamshire and Fig. 1 illustrates, in addition to the present situation, the degree of overloading which it is estimated would develop under four sets of circumstances over periods of 5, 10, 15 and 20 years' time. These categories assume that:

(i) The roads remain unaltered so far as traffic capacity is concerned.
(ii) The Ministry of Transport's anticipated programme is carried out.
(iii) The Ministry of Transport's programme is expanded to ensure that no road is more than 50 per cent overloaded under ultimate conditions.
(iv) The Ministry of Transport's programme is expanded to ensure that no road is overloaded.

A wider survey has been made in Nottinghamshire only, where the reduction in sub-standard roads by the completion of the Ministry of Transport programme is shown to be of little effect in relation to the total mileage—it will, in fact, only touch the fringe of the problem. (Fig. 2). The two suggested hypothetical programmes would each achieve some result that might be considered effective and these are converted to terms of sterling (Fig. 3).

It will be observed under (ii) that, in the light of present-day levels of expenditure, if one makes an optimistic estimate of likely Ministry of Transport expenditure, still no substantial inroad will be made into the road problem. It will be seen that under programme (iii) the work to be undertaken will involve a great acceleration of roadworks, together with a commensurate increase in expenditure of the order of twice the Ministry's present programme. Under programme (iv) to achieve this the Ministry's programme would have to be increased threefold.

At the present rate of expenditure and with traffic increasing at its present rate, it must be envisaged that the situation on our roads will continue to deteriorate.

Motorways

The few motorways which have been built in Great Britain have, in the Minister of Transport's own words, shown that for heavy volumes of traffic the all-purpose road is out of date and it appears to be quite obvious now that all important roads in Great Britain will have to be built as motorways or to motorway standards.

Motorways enable heavy volumes of traffic to flow freely and safely without the interruptions and hazards which are met with on all-purpose roads. Their value is particularly marked when they are constructed to relieve congestion and delays in urban areas. A typical instance of this is the Lancaster By-pass where an economic investigation has been made in accordance with the methods recommended by the Ministry of Transport and the Road Research Laboratory. These investigations have shown that the savings in travel costs and accidents (with deductions for increased road maintenance) amount to £750,100 per year. This represents a return of 17.3 per cent on the capital.

As the amount of traffic on the roads increases so will the savings mount at a greater rate. Assuming the present rate of growth in traffic of 8 per cent per annum is maintained, then the road will have paid for itself in 4½ years.

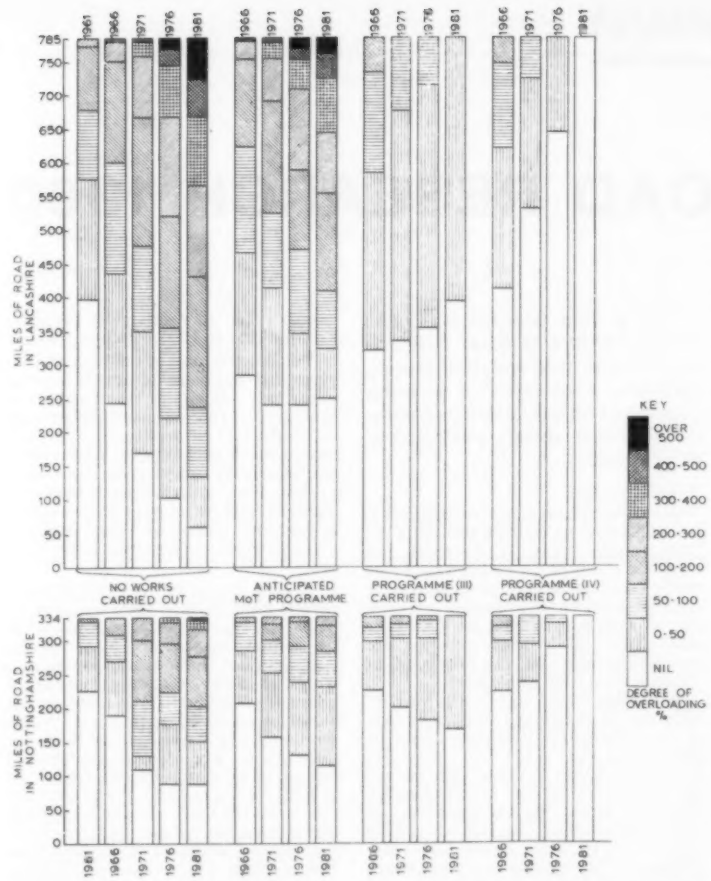


Fig. 1. Combined overloading diagrams of Motorways and Trunk and Class I roads.

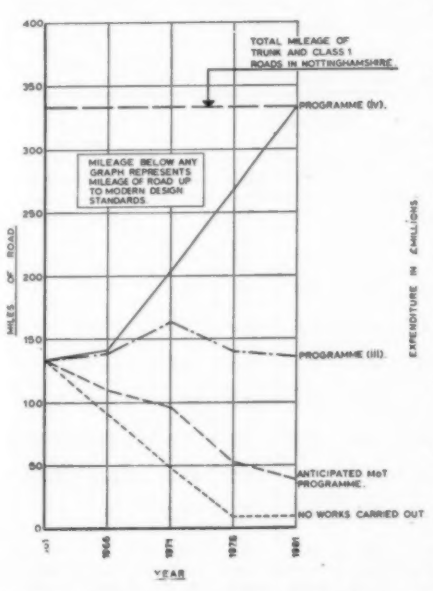

TOTAL MILEAGE OF TRUNK AND CLASS 1 ROADS IN NOTTINGHAMSHIRE
PROGRAMME (iv).
MILEAGE BELOW ANY GRAPH REPRESENTS MILEAGE OF ROAD UP TO MODERN DESIGN STANDARDS.
PROGRAMME (iii).
ANTICIPATED MoT PROGRAMME.
NO WORKS CARRIED OUT
MILES OF ROAD
YEAR

Fig. 2. Graph showing anticipated mileage in Nottinghamshire of Trunk and Class I roads in relation to modern design standards.

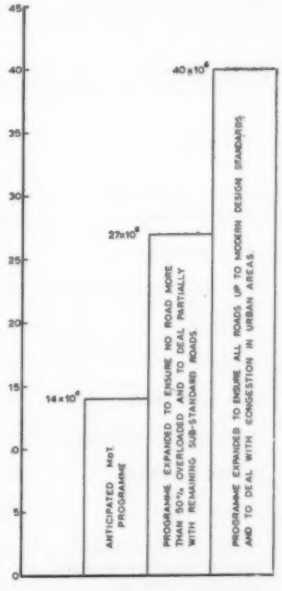

EXPENDITURE IN £MILLIONS
14 x 10⁶
27x10⁶
40 x 10⁶
ANTICIPATED MoT. PROGRAMME
PROGRAMME EXPANDED TO ENSURE NO ROAD MORE THAN 50% OVERLOADED AND TO DEAL PARTIALLY WITH REMAINING SUB-STANDARD ROADS.
PROGRAMME EXPANDED TO ENSURE ALL ROADS UP TO MODERN DESIGN STANDARDS AND TO DEAL WITH CONGESTION IN URBAN AREAS.

Fig. 3. Road programmes for Nottinghamshire covering 20-year period.

One striking fact has emerged during recent years in relation to the planning and construction of motorways, namely the inadvisability of constructing short intermittent lengths of motorways connected by sections of sub-standard all-purpose roads. Motorways attract and generate traffic and, whilst they themselves can cope with large volumes of traffic, they increase the volumes on the existing roads at the terminals to such an extent that serious congestion can occur at certain times, e.g. peak hours; also at week-ends and holidays.

If any serious attempt is to be made to plan intelligently in the future more scope must be given to local highway authorities in the choice of schemes so that selected routes can be dealt with progressively until appreciable lengths of road can be brought up to the standard required.

There is no doubt that the road problem as a whole is already out of hand due to the lack of sufficient funds without which any amount of planning is futile and we shall not see anything but an abortive attempt at a solution in our time if traffic continues to increase at the anticipated rate. What we must attempt to do is to confine most of our attention to the main through routes and bring these up to a safe standard for the 'design' figures for traffic so far as possible. In the past there has been a tendency to carry out schemes on a 'piecemeal' plan, e.g. to eliminate sharp bends and accident black spots. Whilst this has much to commend it, as an interim safety measure, in many cases these schemes should be superseded in the foreseeable future to meet the demands of increased traffic, or much of the expenditure incurred will be rendered abortive.

Surely in these enlightened times such a policy cannot be allowed to continue. It is therefore contended that for any plan to be worthwhile it must at least be of sufficient magnitude to enable the improvement of road conditions to keep pace with the ever growing demands of traffic. As can be seen from Fig. 2, discussed when dealing with 'The Magnitude of the Problem', a further 190 miles of existing road in Lancashire and Nottinghamshire would be overloaded within five years and a further 350 miles within 10 years if the roads remain unaltered so far as traffic capacity is concerned. Even a road programme which provided only for the avoidance of such increases could not be regarded as satisfactory.

With the announcement of a realistic programme, highway authorities would be able to plan ahead and to concentrate their efforts with a sense of fulfilment on this worthwhile objective. It would be possible to make the necessary arrangements for land acquisition and to carry out all necessary negotiations with interested parties to ensure that construction work could proceed smoothly at the scheduled times.

In the absence of a comprehensive plan there will remain the present conditions of vacillation between schemes with its consequent diversification of effort and poor use of manpower, combined with the frustrating realization that in spite of all efforts road conditions must become steadily worse.

ROAD RESEARCH 1960

THE Report of the Road Research Board with the Report of the Director of Road Research, Sir William Glanville, contains the record of work undertaken and results achieved during the last year.* Much of this has already been reported in *Traffic Engineering & Control* since several papers have been contributed to this Journal during the year by the Road Research Laboratory. The following extracts from the Report should, therefore, be regarded as additional to these.

Regarding Traffic Engineering the Board states:

'We have urged in previous reports the country's need for traffic engineers and have recommended that more traffic engineering research should be carried out in our universities. We are glad to record, therefore, that 40 representatives from 21 universities and other interested bodies attended in April a one-day conference organized by the Laboratory. This conference strengthened the links between those teaching and conducting research in traffic engineering and is a useful step towards greatly increased co-operation in the whole of this field. We are interested to note too that courses of lectures in this subject have now been organized at a number of technical colleges. The Laboratory continues its own courses and assists the universities and technical colleges where possible.

'As traffic increases, the loss of time at intersections increases more rapidly than at other parts of the road system and, of the specific traffic engineering problems to which we have devoted attention, we would mention that of the control of traffic at intersections. We have studied the encouraging results of the experiments made by the Laboratory in 1959, in which traffic signals were used to control entry to certain roundabouts, and we have recommended that further research should be carried out as soon as possible on the effect of this method of control. We have also recommended that the useful work which has already been done by the Laboratory on methods of increasing the capacity of traffic signals and reducing the delays at them should be further continued. We recommend that full use should be made of the research results already obtained on the timing of traffic signals.

**Road Research* 1960, *H.M.S.O.* 7*s.*

The section devoted to Traffic by the Director of Road Research covers a wide field and the following data have been extracted as being considered of special interest, additional to that already published in these columns.

Traffic Trends

'Information about trends in traffic flow has continued to be obtained from 50 points representative of the trunk and classified roads of Great Britain. Automatic counters have been in operation at these sites since 1956 and periodic manual counts have been made at them since April, 1957. These censuses are arranged jointly by the Ministry of Transport and the Laboratory.

'Estimates of the total miles run by different classes of vehicle on the roads of Great Britain in 1956 were given in *Road Research*, 1959 (p. 8). The automatic counts provide information on overall traffic trends ard the manual counts indicate the composition of traffic in each year. Manual count data were used to break down the total mileage of motorcycles into four classes and that of goods vehicles into two classes, in addition to the classification into types used in earlier reports. Scaling up all these figures in the light of the trends shown by the automatic counts at the 50 points gives the mileages for 1957 to 1960 shown in Table I.

'Published figures of licensed vehicles permitted estimates of annual average miles per vehicle to be made. The estimates for 1956 and 1960 are included in Table I. The decline in miles per motorcycle is probably due to increased use of scooters and mopeds, which tend to have lower mileages per vehicle (see Table I). The miles per vehicle for two of the other classes of vehicle indicate a slight tendency for them to be used more.

'Trends in the flow of each class of vehicle from 1956 to 1960 are given in Table II. Scooters and mopeds show the greatest upward trend in mileage. The trend for light vans is comparable with that of cars and larger than that of heavy goods vehicles. Solo motorcycles, motorcycle combinations and public service vehicles have shown little change since 1956. The rate of increase of mileage of all motor vehicles from 1958 to 1959 was 12 per cent per year, whilst that from 1959 to 1960 was 7 per cent. The average annual rate of increase (on a compound basis) was 8 per cent from 1955 to 1960. The summer of 1959 was unusually fine and the summer of 1960 was much wetter than normal. The figures therefore suggest that the rate of increase of mileage of all vehicles may still be increasing.

TABLE I

Estimates of miles run by different classes of vehicle in Great Britain 1956 *to* 1960.

Class of vehicle	*Vehicle-miles* ($\times 10^9$)					*Miles per vehicle*	
	1956	1957	1958	1959	1960	1956	1960
All motorcycles ...	4.5	5.0	5.0	5.8	5.9	3,400	3,200
Solo motorcycles ...	3.1	3.3	3.1	3.4	3.3		
Motorcycle combinations	0.7	0.8	0.8	0.8	0.7		
Mopeds	0.2	0.3	0.3	0.4	0.5		
Scooters	0.4	0.6	0.8	1.2	1.5		
Cars (incl. taxis) ...	30.7	30.0	36.8	41.2	44.9	7,800	8,000
Public service vehicles	2.6	2.5	2.4	2.5	2.5	31,000	31,000
All goods vehicles ...	14.2	14.0	15.6	17.3	18.4	11,000	12,000
Light vans	5.7	5.8	6.6	7.6	8.3		
Other goods vehicles...	8.5	8.2	8.9	9.7	10.1		
All motor vehicles ...	52.0	51.5	59.9	66.9	71.7	7,800	7,900
Pedal cycles	10.6	10.5	9.2	8.9	7.9		

TABLE II

Trends in traffic flow in Great Britain 1956 *to* 1960

(1956 = 100)

Class of vehicle	1956	1957	1958	1959	1960
All motorcycles	100	111	112	130	132
Solo motorcycles... ...	100	105	98	109	104
Motorcycle combinations	100	106	109	107	99
Mopeds	100	128	139	176	204
Scooters	100	161	208	312	382
Cars (incl. taxis)	100	98	120	134	146
Public service vehicles ...	100	96	93	94	94
All goods vehicles	100	99	110	122	129
Light vans	100	102	117	135	146
Other goods vehicles ...	100	97	105	113	118
All motor vehicles	100	99	115	129	138
Pedal cycles	100	99	87	84	74

Increases in motor vehicles

'Recent trends in traffic flow and vehicle ownership probably give the most reliable guide to trends over the next five years or so. Past experience, however, indicates that long-term predictions of future vehicle ownership cannot be made by simple extrapolation of past trends. A recent comparison of rates of growth in different areas has, however, enabled a new assessment to be made of the prospects for the more distant future.

'The annual percentage rate of increase of motor vehicles per head of population during the period 1956 to 1959 in counties or groups of counties in Great Britain was examined. In those counties where at present there are more vehicles per head, the rate of increase tended to be less. Assuming a straight line relation between these quantities it can be deduced that an area with about 0.6 vehicles per head would not be showing any further increase, but that in any area with fewer than this the number of vehicles per head would still be increasing. Thus 0.6 vehicles per head may be regarded as the current saturation level. Similar calculations have been made for periods before 1956 and also for the United States of America, and the saturation levels obtained are shown in Fig. 1. Thus in Great Britain the saturation level has been rising steadily to its present value of about 0.6, while in the United States it has for some years been fluctuating about a constant level of about 0.7. Whether these saturation levels will ever be achieved is of course uncertain, but they can perhaps be regarded as minimum estimates of the ultimate demand, provided that there is sufficient economic progress to enable this demand to be satisfied.

'Accepting 0.6 vehicles per head as the ultimate level, and assuming a current rate of growth of 7 per cent per year, Fig. 2 shows how the level of ownership in Great Britain may develop over the next 50 years assuming that the population will rise to 60 million. The curve gives the following estimates of numbers of vehicles licensed in various years:

1960	9 million
1970	17 million
1980	25 million
1990	30 million
2000	34 million
2010	36 million

Traffic studies and control

'*Electronic computer programmes.* An electronic computer is of great value in dealing with the very large quantities of numerical data involved in studies of traffic. A programme has been written for the analysis on a Ferranti "Pegasus II" computer of speed-data tapes produced by the recording speedmeter (described in *Road Research*, 1958). The speeds are recorded on standard five-hole tape and classified, by the observer who is operating the recording speedmeter, according to type of vehicle. After the addition by hand of information on traffic flow (recorded separately) to the speed-data tape, it is ready for the computer.

'The programme can combine data for several periods and it prints out a foolscap page of results with a column for each of six types of vehicle and a final column for all vehicles. Each column gives the percentage distribution of speeds and the mean speed with its standard error. The table is headed with information about the site and flow-conditions and contains all the information required for the study of the results Approximately 850 speeds per minute can be processed in this way, the final output of results on the computer taking about another minute.

'A method of allocating traffic to a network of roads was described in

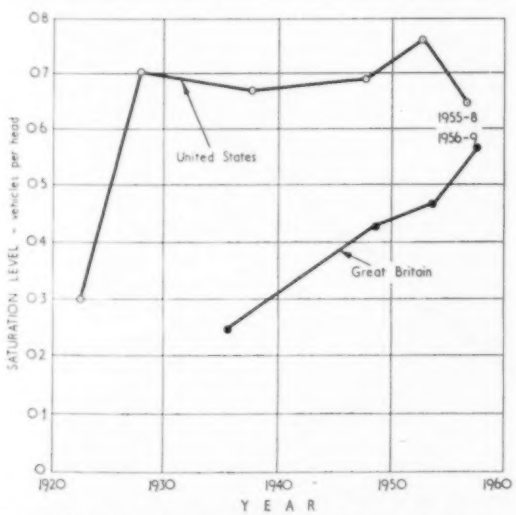


Fig. 1. Variation of saturation level of vehicles per head over 5-year periods.

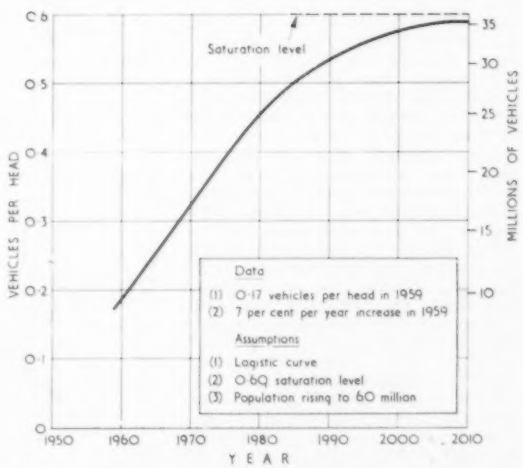


Fig. 2. Future course of vehicle growth in Great Britain on the basis of certain assumptions.

Road Research, 1959. Two complementary computer programmes have been written for the computer to enable it to allocate known traffic movements to a network of roads, assuming that traffic travels to its destination by the quickest route available. The programmes may also be used to carry out allocations by the 'cheapest' route if necessary, where the cost depends on such factors as speed, distance, number of stops, etc. The results of the allocation consist of the flows along each portion of route and the turning movements at each intersection. These figures provide information for the design of the roads and of the junctions and can also be used for assessing the relative benefits of alternative schemes in terms of vehicle-hours or of monetary gains and losses.

'The preparation of the data for allocation involves the selection of a basic network to represent the area under consideration and the division of this network into sections. Journey times from the centre of each section to the centre of each adjacent section have also to be obtained. From this information a punched paper tape defining the network is prepared for input to the computer. Origin-destination information can be provided in the form of movements between sections or alternatively in the form of movements between zones containing several sections. In the latter case it is also necessary to provide a list defining the proportion of a zone's traffic which is estimated to terminate in each section. This flow information is also punched on to a paper tape, which together with the network tape forms the data for the first programme.

'The first programme calculates the quickest route between each pair of sections and allocates the traffic flow between them to the roads forming the quickest route. The output gives the turning movements at each junction. The total time in seconds taken by the computation and output is approximately equal to $\frac{1}{3} \times$ (number of sections) $\times$ (4 + the number of sections which are traffic origins). The second programme is used to combine in desired proportions the allocations produced by the first programme for each type of driver. The output from the programme gives the flows and turning movements converted from the units used in the computation to vehicles per hour. Computation and output of the second programme take about $2\frac{1}{2}$ seconds per section in the network.

'The electronic computer has also been used in connexion with the "moving observer" method for studying traffic conditions over a large area. This method has been used since 1947 to obtain information about conditions in London and other large cities (see *Road Research*, 1948, p. 28). A computer programme has now been written so that the paper tape obtained during the traffic survey can be fed directly into a computer. The "flow and journey times" programme averages the data from a number of survey tapes and produces journey time in minutes, and flow in vehicles per hour, on each road section in each direction for two classes of vehicle and the journey time for both classes together. The mean and the standard deviation of the journey time along each section and the stopped time at each intersection in each direction are also produced.

'A simpler "survey analysis" programme is also available which de-codes and prints out data from a single survey tape.

'*Traffic counter*. A simple accumulating traffic counter, largely developed at the Laboratory, has recently been made available commercially. Experience suggests that the number of failures per million axles counted was less than half that of the counter which it replaced. The main features of this instrument are a more robust construction, easier maintenance and an improved diaphragm adjustment assembly which prevents damage to the beryllium copper diaphragm.

'*Vehicle-presence detector*. In the course of traffic investigations it has become clear that a detector that responds to the presence of a vehicle whether moving or stationary might have useful applications in such problems as (i) the detection of stationary vehicles which are obstructing traffic, (ii) the detection of jammed traffic conditions at bottlenecks such as roundabouts, signals and tunnels, (iii) a count of vehicles where it is important that each vehicle should count as one unit, e.g. at a toll booth, (iv) as a research tool to be used for semi-theoretical studies of the relation between speed, flow and density along a road. Two alternative "vehicle-presence" detectors are being developed, the loop detector and the Hall-effect detector.

'A loop detector to respond to vehicles is being developed from a commercially available metal detector. The detector consists of two parallel loops of cable normally placed on or beneath the road surface, one loop being energized with an alternating current of 2 kilocycles per second. There is a pick-up of this signal in the second loop, due to the mutual impedance between the loops, and the presence of metal near the loops causes a change in the mutual impedance between them and consequently a change in the signal collected by the pick-up loop. A feature of the circuit used is that the detector is relatively insensitive to small changes in loop size and consequently a fair degree of stability can be achieved. The size of detector loop used with the commercially available equipment can be between 2 ft. $\times$ 2 ft. and 25 ft. $\times$ 5 ft.

'The Hall-effect detector utilizes the Hall effect in a semiconductor. This detects small changes in the earth's magnetic field which are caused by the presence of ferromagnetic material in the vicinity. A prototype of the detector has been demonstrated and has indicated the presence of cars several feet from the detector. In some cases, therefore, this detector may be placed at the side of the road rather than being buried beneath it.

'Present work with vehicle-presence detectors is aimed at assessing their suitability for the applications listed above.

'One of the applications is in connexion with the control of roundabouts by signals where vehicle-presence detectors could be used to indicate that traffic is approaching the point where it comes to a standstill, i.e. locking is imminent. The signals could then automatically be set to "all-red" to allow vehicles to disperse freely. Green signals would be shown when the roundabout ceased to be congested. The number of vehicles in the roundabout

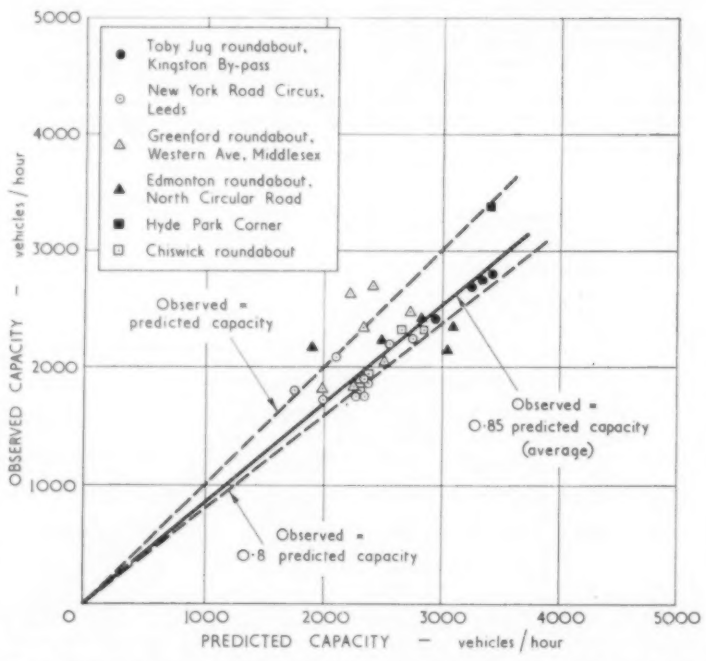


Fig. 3. Comparison of observed capacity of a weaving section with value predicted using the Laboratory's formula.

could be detected either by a large loop round the roundabout or by a number of Hall units around the central island.

'Apparatus has also been developed to convert the output from a vehicle-presence detector into a measure of the average density of traffic over it during a period. In particular, this has been done in connexion with the study of the possibility of automatically diverting traffic away from congested points in a road network.

'*Area traffic control.* Considerable interest has been shown in the possibility of using electronic methods to ensure the best use of the existing road system. A meeting of interested commercial organizations and government departments was held at the Laboratory and reports were subsequently submitted by the bodies concerned suggesting possible programmes for research and development of suitable equipment. It was clear that the basic need was for further traffic research at sites where such automatic methods of control might prove beneficial. The problem has been considered in two parts (i) the diversion of traffic away from congested points in the network, and (ii) the co-ordinated control of a large number of signals on an urban network such as is found in Central London. In considering the control of a large number of signals, a simulator capable of simulating a large network of signals would be desirable and recommendations have been made that, since such a piece of equipment would be a useful research tool, preliminary investigations as to its feasibility should be made.

'As part of the work on the diversion of traffic in networks, a small computer has been developed which will assess the shortest route between two points in a network of roads and give information about the journey time on each link. A small demonstration model using stepping switches has been produced; it is based on the assumption that every link making up the network is either open to traffic (with a known journey time along the link), or is considered as closed as a result of severe congestion (automatically revealed by density detectors). Thus the problem is to determine the shortest route from the origin to any destination on a network of links, the length of each link being proportional to the journey time; these links may be either open or closed. The computer simulates movement from an origin in all directions along the open part of the network of links at a constant speed, and the route by which a particular point is first reached is necessarily the quickest route.

'*Capacity of a roundabout.* A method has been devised for determining the capacity of the individual weaving sections of a roundabout and has been used to study several roundabouts in and near London. Although these observations are continuing, provisional results are shown in Fig. 3, which compares observed capacities with those predicted from the results of the Laboratory's weaving tests on an airfield (reported in *Road Research*, 1957, p. 22). The results so far indicate that the mean observed capacity is about 85 per cent of the predicted value but the scatter of the results is appreciable. It will be seen from Fig. 3, however, that all but one of the points lie near to or above the line "observed capacity — 0.8 × predicted capacity". If, therefore, a roundabout is to be designed with a reasonable chance of the real capacity being at least as great as the design capacity (even allowing for the effect of wet weather which has been found to reduce capacity by about 10 per cent), then the latter value should be about 0.8 times the value based on the results of the airfield tests. With large weaving sections, better agreement between prediction and practice has been obtained and this is probably because interaction between weaving sections is not a serious problem with this type of roundabout, whereas it is the main problem with small ones and is the one which initiates "locking". In the Laboratory's tests the weaving sections were "open ended" and had no interaction effect. Refinements which may give better predictions of the capacities of small roundabouts are being sought.

'Delays at six roundabouts have been measured and the results obtained are given in Fig. 4. The continuous curve gives the mean value and could be used to give a first approximation to the delay at a roundabout. The actual delay (to be used, for example, when comparing with signal control) is the delay shown in Fig. 4 plus the extra time taken to negotiate the roundabout (at, say, 15 mile/h.) over and above the time taken to travel along a straight path at the average running speed of the particular road. It should be noted that these curves refer only to free running conditions, i.e. no locking took place during these observations. As a roundabout approaches capacity the delay rises rapidly. In practice there is no set curve for the delay in this region as it depends on whether the roundabout remains free flowing or whether it starts to lock, in which case the curve turns back on itself as the delay rises and the number of vehicles passing through the roundabout diminishes. One such case is shown in Fig. 5. This roundabout was subsequently improved by increasing the size of the central island and lengthening the weaving sections; the new delay curve is also shown in Fig. 6. Locking is liable to take place at flows considerably lower than the maximum which can be obtained, and at one particular roundabout locking sometimes occurred when the flow was only 80 per cent of the maximum observed under free-running conditions.

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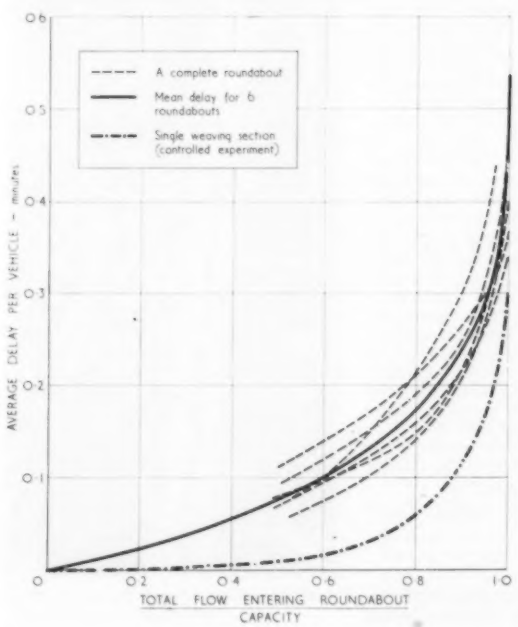
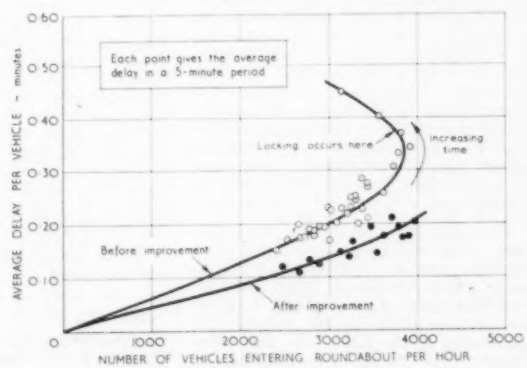


Fig. 4. Delay/flow curves for six roundabouts (ignoring the effect of locking up).

Fig. 5. Delay/flow curves before and after an improvement at a roundabout on the North Circular Road at Edmonton.



Report from Washington

DESIGN AND OPERATION OF RURAL FREEWAYS

At the World Traffic Engineering Conference in Washington, Charles M. Noble, Consulting Engineer and Member of the Institute of Traffic Engineers, was General Reporter on Theme III, the *Design of Interchanges on Rural Freeways*. Extracts of his report on papers from various countries are given below. These are followed by extracts from the General Report on Theme VI, *Freeway Operation*, given by K. Vaughan-Birch, Director of the Traffic Division, Engineering Department, Vancouver.

THE controlled access highway or freeway is the safest, most comfortable and efficient roadway thus far developed for the free-wheeled automotive vehicle. Some of these roads have achieved the remarkable record of having a fatality rate of less than one death per 100 million vehicle miles of travel. These highways safely carry large volumes of fast moving vehicles with ease and comfort. Although the great bulk of roadways throughout the world will continue to be of the two lane, at grade, land service type, the controlled access highway is destined to receive more and more attention along the main arteries of travel. Therefore, the more we know about this type and what constitutes proper design, the greater service we can render mankind.

Thus, as responsible engineers serving the public, it is our duty to explore every facet of freeway design. We must assure ourselves that we are pursuing an enlightened course which will provide long lasting safe and adequate facilities at the lowest economic cost, rather than a shortsighted wasteful policy that results in inadequate designs that will cause congestion and kill and maim people. Ultimately inadequate facilities will have to be rebuilt at greater cost.

Provided good geometric standards have been utilized in design, the open freeway does not present the motorist with many problems when driving, and the course of the highway designer is clear as long as he follows the geometric guide lines. On the other hand, in the design of an interchange, standard forms, geometric standards and policies are useful tools, but these do not relieve the engineer of the responsibility of applying resourcefulness, technical skill and sound judgment. Each interchange is a separate and individual problem that must be based on the facts and conditions surrounding each site.

It must be recognized that the interchange is a special place of hazard and confusion to the motorist. We must also recognize that the very nature of the controlled access highway—with its relaxed, effortless driving—breeds in the motorist inattention and day dreaming which large signs do not always overcome. Thus there should be as few of these confusion areas as possible, consistent with reasonable service to the public.

In designing and comparing costs there is a natural tendency to overestimate the comparative cost of design elements and details that make up a complete interchange. Too often it is forgotten that interchanges occur at intervals only, that certain features are inescapable (such as land, bridges, grading, ramp lengths, etc.) and the cost of making all elements fully adequate to do the job that should be done costs very little when viewed in the light of the cost per foot or per mile of the entire completed highway.

From the following countries papers were received.

Australia

Mr. Henry George, Divisional Engineer, County Roads Board, Victoria, notes

A Diamond Interchange on an American Freeway.

that Australia has no freeways yet in operation and consequently their engineers have drawn heavily on experience abroad. A section of freeway is expected to be opened this year.

He notes that the planning and design of rural freeways, the spacing and selection of interchange types in the State of Victoria are aided considerably by the active use of town and country planning legislation particularly in the vicinity of urban areas. Where local authorities have not commenced planning, the State Government has directed that central planning agencies prepare plans to insure that planning on a regional basis conforms with overall community needs. Refreshingly he states that it is not wise to place complete reliance on land use planning, because such plans can be changed or modified and the actual development of land may take place in a manner entirely unexpected.

Rural Interchange

Concerning rural interchanges, it is pertinent to note that most on the new Interstate System in the United States are of the diamond type and recent operational improvements have resulted in this type handling surprisingly large traffic volumes. The cloverleaf on the other hand gets 'in irons' under heavy volumes and is very inefficient unless equipped with collector/distributor roads. Such roads also simplify the signing problem and avoid blind turns from the high speed main lanes beyond the cross road bridge. It would appear that a cloverleaf design could hardly be justified unless collector/distributor roads are included, because of the tremendous land area covered by a cloverleaf design. (40 acres is not unusual).

Concerning details, all has not yet been said concerning the direct taper off-ramp on high speed roadways. The identification or target value of full width parallel deceleration lanes is superior, particularly in adverse weather. Merging or acceleration lanes should merge in a straight line as indicated in the California studies, but drivers should be compelled to straighten out into the merge direction by the use of a barrier kerb. Any curvature, however slight, beyond the barrier kerb will induce many drivers to cut into main freeway lanes too quickly. Most certainly it is agreed that the entrance and exit ramp noses, should be off-set the full shoulder width and that vehicles approaching the freeway should have a clear view of the freeway vehicles. On loop ramps it is agreed that maximum loop sizes should range from 180 to 200 ft. although loops as small as 125 ft. radius have been operated successfully if preceded by an ample transition. But it is felt that 0.08 ft. per foot superelevation (cross fall) will cause traffic blockades in areas subject to ice and snow. Mr. Noble agreed concerning the objection to ramps that take off to the left rather than to the right in countries that drive to the right. Concerning off ramps occurring on the outside of curved freeway alignment, these should be avoided unless designed so the motorist is not induced to take the ramp when he really wishes to continue on the freeway.

Austria

Concerning the number and location of interchanges it is well to repeat that interchanges are hazard and congestion points and as few interchanges should be constructed as possible. In many areas the criteria that interchanges must be provided wherever traffic requires them and they are economically justified will result in transforming the freeway into a local facility that gives great service to strictly local traffic at the expense of the longer distance traffic. The large capital and maintenance cost of the freeway will be jeopardized. This loss will far outshadow the benefits to purely local traffic that should be moving on the local road system anyway.

If we are to have an economical highway system the freeway must be considered as a long range investment, not one that is obsolete the day it is opened to traffic. In most heavily developed areas interchange spacing from six to ten miles furnishes adequate local service with little loss to the longer distance traveller.

Inasmuch as the design of acceleration and deceleration lanes is subject to some controversy, more detailed remarks concerning them may be helpful. First, Mr. J. R. Dorfwirth, Technische Hochschule, Vienna, uttered a great truism when he stated that all interchanges should be provided with acceleration and deceleration lanes of the necessary length, even at secondary interchanges. He was quite correct since disasterous fatal accidents can happen at secondary interchanges as well as elsewhere. With reference to deceleration lanes, seldom mentioned is that these lanes need to have target value in all kinds of weather and at night. The motorist needs to have his attention almost forcibly directed to the presence of the lane. There is need also for recognition distance. This is why deceleration lane lengths calculated from geometric principles alone are inadequate for the motorist. Missing an interchange exit on a freeway is an unpleasant experience when it may be necessary to proceed some miles farther before being able to turn about, return and exit. The economic loss to the motoring public from this manoeuvre can be substantial.

Belgium

Mr. Edmond M. Goelen, Chief Roads and Bridges Engineer, Ministry of Public Works, stated that interchanges are the most important part of rural freeways from the traffic point of view, but in the past too little care went into their design, and that sacrifices were made because of local considerations. He warned that skimping or ill-considered designs are uneconomic and require rebuilding as traffic develops, and noted that past designs have tortuous vehicle paths, lack of progressive transition curves, badly designed or too short merging lanes and faulty layout of channelizing islands where interchange ramps join the local road system. He also pointed out the unsuitability of circles or roundabouts for motorways, or as their terminals, and stated 'the design features of roundabouts are incompatible with the needs of motor traffic'. Diamond interchanges are becoming increasingly popular in Belgium.

It is pertinent to observe that the average spacing of interchanges on the existing Brussels-Ostend motorway is a little under 10 kilometres, that the average daily traffic on the motorway is 16,000 vehicles per day and on the cross roads 2,000 to 7,000.

Germany

Counseller Fritz Heller and Dr. Ing. Wolfgang Blaschke, Federal Ministry of Transport, Bonn, stated that 'In developing the interchanges, the task of the engineer is, inter alia, that of making it possible for vehicles which change their direction to reduce and increase speed without danger.' Another important principle that is applicable to all highway design, particularly interchanges, is making the design such that it suits the preference and inclination of the driver so that he will subconsciously choose the safe and correct act or manoeuvre.

The Authors made observations and measurements at some old freeway interchanges which at exits show, (1) the vehicle tracks differed but slightly from one another; (2) that tracks were on a curve and (3) the tracks did not follow the lane marked out. These observations also showed that 'long before the interchange point, on discerning the exit point or sign post at the exit point, the foot was taken off the accelerator and the vehicle glided without propulsion to the interchange point.'

As a result of these observations and studies German freeway interchanges are no longer provided with parallel deceleration lanes. Instead, the exits have been made on the basis of brake curves preceded by tapering areas 150-200 metres long for the purpose of ensuring safe and speedy departure from the main carriage way.

Turning now to the acceleration lane, it is noted that in Germany they are having the same difficulty experienced in the United States until a barrier kerb was installed on the entry ramp near the start of the acceleration lane. Observations in Germany show that in spite of an acceleration lane the majority of vehicles cut into the main carriageway and accelerate there. A properly designed barrier kerb will generally control this tendency and guide drivers to choose the safe procedure. The kerb should not be placed closer to the main carriageway than the outer edge of the shoulder (berm or strip) generally 10 ft. from the edge of the main carriageway and it must be carried sufficiently along the edge of the entry ramp and acceleration lane that the motorist no longer feels the pull of centrifugal force, has straightened the vehicle out along the course of the acceleration lane and can see the open acceleration lane straight ahead. The angle of approach of the acceleration lane should be sufficiently small for vehicle drivers on it to see vehicles on the main carriageway in their rear view mirrors. The acceleration lane shoulder should be full width (minimum 10 ft.), adequately paved and free from obstructions or kerbs to obtain the correct reaction from the driver.

The paper indicated that for lorries (trucks) and presumably for level grade, the length of the acceleration lane is nearly 1,700 ft. long which is greater than customarily used in the United States. However, this length may be conservative and fully justified by conditions in Germany. The added cost of the greater length will be quite small when viewed on the basis of the cost per foot (or metre) of the entire completed highway. The improved length can only increase the safety and traffic efficiency of the facility.

Japan

Dr. H. Sato (Director), Mr. N. Katahira (chief of Nagoya-Kobe Expressway Department) and Mr. T. Tase (Traffic Engineer) of Mihon Doro Kodan, stated that the design problem was complicated in Japan by extreme shortage of land, heavy population concentration, rapid vehicle registration, difficult topography subject to earthquakes and complications due to the highway being a toll road. In addition there are large numbers of bicycles on the existing highway and street system. Buses and trucks comprise a large proportion of the total traffic and bus stops are required. Because of these conditions much of the data obtained abroad was not applicable and the Japanese engineers developed new techniques in the design and construction of interchanges. Many of the interchanges will be of small compact size based on utilizing the lowest limits of design standards. The design speed of the expressway varies, being 120 km./h., 100 km./h. and 80 km./h. Due to the toll road feature most of the interchanges will be of the trumpet or double trumpet type.

All engineers could well follow the lead of Japanese engineers in recognizing the importance and of making sure that a completed facility will present an aesthetic appearance.

United Kingdom

Mr. J. G. Smith, Deputy Chief Engineer, Ministry of Transport, said the minimum spacing of interchanges in Great Britain has been established to permit reasonable distances between acceleration and deceleration lanes and for signing. Maximum spacing is about 12 miles to provide access for police, ambulance, breakdown and maintenance services. Originally it was assumed that average spacing of interchanges would be about seven miles. However, in practice the spacing turned out to be about 5½ miles, which was found satisfactory.

In view of the unfavourable experience in Belgium with a roundabout as a terminus to a freeway further comments by Mr. Smith on his experience would be useful. In the United Kingdom, roundabouts are the termini of the motorway. Roundabouts on the ordinary state highway system in New Jersey, U.S.A. have been unsatisfactory and have a poor accident record.

The statement that diamond interchanges are suitable only where traffic is light is contrary to experience in the United States where recent techniques have resulted in the diamond handling quite heavy flows of traffic.

United States

Mr. George A. Hill, District Engineer, California Division of Highways, set forth excellent guiding principles for interchange designers. His eight golden rules are as follows:

1. The best design is generally the most simple one that will do the job.
2. The outer freeway lane is generally accepted as the proper lane for slower traffic and for on and off movements. Conversely, the inner high speed lanes should be protected from the slower on and off movements.
3. The designer should always try to use consistent, familiar patterns which simplify as much as possible perception, decision, and reaction by the driver.
4. Adequate warning of impending on and off movements must be provided.
5. On and off ramps should be confined to one lane operation to better control, channelize and simplify as much as possible these manoeuvres.
6. Easy, well controlled operation from the use of high design standards invariably carries with it high capacity and greater safety.
7. The driver should be presented with only one decision at a time and points of decision should be separated by adequate distance to allow for driver reaction time.
8. Maximum day and night visibility of interchange areas of decision should be provided.

The Author clearly recognized the need for good freeway alignment and excellent visibility at interchanges particularly with respect to the exit nose. It is noted, however, that with the diagonal type deceleration lane the target value of the exit is lowered. Since this type of design is also used in Germany and favoured in Belgium there should be a discussion concerning the relative merits of parallel and diagonal deceleration lanes.

Mr. Hill laid down three rules that should be followed in exit ramp design:

1. Adequate advance signing of the impending opportunity to leave the freeway which demands a change of direction and type of operation.
2. Excellent sight distance to the actual physical ramp connection.
3. The change in design standards between high freeway standards to lower ramp standards must be accomplished gradually, to allow driver orientation.

California extends access control along ramps to the connecting road and this would seem to be the minimum requirement. Actually many cases have been observed where access or zoning control is needed on the cross road in the vicinity of the interchange.

On the acceleration side Mr. Hill noted the need for high type approach alignment at the merging area. He stated that . . . 'the on ramp should provide time-distance for re-orientation of driver attitudes from local road to freeway operation . . . The vehicle should approach the merging area behind the physical protection of the gore area, at a flat approach, at nearly the same grade and with adequate intervisibility with the freeway lanes.'

In discussing interchange types, he designated the diamond type as the 'workhorse' providing the simplest, most foolproof type of operation. With the ramps widened to two or even three lanes near the cross road, volumes up to 1,800 vehicles per hour are possible. Concerning the cloverleaf, he felt that loops should not take off from the freeway directly, as it is difficult to provide desirable driver re-orientation between high speed freeway operation and sharp loop ramp operation; that collector roads to eliminate freeway weaves and increase driver re-orientation are highly desirable. Mr. Noble went further, in that because of its limited traffic capacity, cost and large usage of land area the conventional cloverleaf is seldom justified, only being justified when it is equipped with collector roads. In addition, the collector roads act as storage areas which may prevent the interchange getting 'in irons' during heavy traffic flows. Care must be exercised in designing the exit side so that the take-off of the collector road is spaced far enough from the deceleration lane nose for the principle to be held of presenting the driver with only one decision at a time.

Summary

(*a*) There is unanimous and positive acceptance that freeway interchanges should be equipped with acceleration and deceleration (merging) lanes. There is no agreement on the details of design or on the length of the lanes. The principle division concerning design detail is whether the deceleration and acceleration lanes should be parallel to the main freeway or should depart from or approach it at an angle.

(*b*) There appears universal acceptance of the principle of design speed although neither California nor United Kingdom mention it.

(*c*) Australia, Austria and California stipulate that the driver must not be presented with more than one decision at a time, that he should be given time and space to adjust himself to roadway or traffic changes, and they stress the need for intervisibility at interchanges between traffic on merging and diverging ramps and the freeway proper.

(*d*) Belgium, United Kingdom and Japan construct hard shoulders on ramps while Japan and United Kingdom utilize a median divider on ramps carrying two way traffic.

(*e*) Japan and Germany use the clothoide curve for transitions.

(*f*) Belgium noted that diamond type interchanges are increasingly popular in that country while California is quite partial to this type. On the other hand, some authors indicated that the diamond has low traffic capacity.

(*g*) The type of interchange selected should be chosen to fit individual site and traffic conditions rather than be a standardized design regardless of topography, cost, traffic, local road patterns or other local conditions.

The United Kingdom has shown the way in the establishment of a Traffic Engineering Committee specially convened for the study of freeways. Mr. Noble suggested that every country should establish a similar activity carried on continuously, so that necessary adjustments and corrections in design practices will be promptly detected and action taken.

Above all, let us get away from the minimums in providing motor traffic facilities. It is too much to ask the traveller to risk his life on minimums—drivers usually drive by maximums. Often they cannot adjust to minimum designs, and the driver needs and is entitled to a factor of safety.

Freeway Operation

BRIEFLY, freeway operation can be summarized under two main headings. The first is the maintenance of the facility itself and the second the maintenance of the traffic using the freeway.

The high speed characteristics of vehicle movement on freeways is mentioned as one of the main factors which differentiates the freeway from the normal grade street. As indicative of the importance of this speed factor it was concluded from the Freeway Operation Seminars which were conducted by the Institute of Traffic Engineers last year, that 'factors which force traffic to reduce speed will contribute to accidents'. In Mr. Rieckenberg's paper and also in the paper prepared jointly by Doctor Berti and Doctor De Amicis reference was made to the restrictions applied in Germany and Italy which limit the traffic permitted to use the motorways to those vehicles which are able to maintain a given minimum speed.

In general, operation difficulties can, to a large extent, be avoided by careful planning of the geometric design of the freeway and the service facilities. As an example of this, Mr. Rieckenberg stressed the matter of reduction of accidents brought about by improvement in design.

Snow and Ice Control

The removal of snow and the correction of icy pavement conditions are matters which Mr. Ricker of the United States, and Mr. Rieckenberg of Germany, felt require careful organization so that prompt attention can be given. Mr. Rieckenberg expressed the view that it would be technically unfeasible and financially impossible to keep the entire length of all motorways cleared of snow and ice. The policy in Germany is to treat the specially dangerous points, for example, stretches on steep grades, bridges which tend to become iced over, etc. He dealt at some length with the trend to decrease the amount of sand and increase the quantity of salt used for combating these winter conditions.

Maintenance of Flow

Dr. Berti and Dr. De Amicis theorized that there can only be two reasons for summoning aid on freeways:

(*a*) a mechanical breakdown of the vehicle,
(*b*) an accident involving injury to the person's concerned.

It is, therefore, clear that contact between the driver and the central station can be made more simply by means of a press-button machine than by telephone . . . The machines which are placed in pairs about every mile or so have two buttons, one for mechanical breakdowns and the other for accidents. This Italian system appears to have considerable merit since it should avoid, as far as possible, the confusion that can arise when a motorist is in an excited state of mind.

Toll collection presents some as yet unsolved problems, and on the new and longer motorways in Italy which are not connected with the old ones, more modern systems not involving the issuance of tickets have been adopted, making use of the United States long experience in this field.

Talking about the effect on the cost of transportation, Doctor Berti cited average running costs, the amount of increase due to the toll, and the lower running cost of motorway travel. On the basis of this information he said 'the money saved by using the motorway and the cost of tolls run out about even. This is speaking in the strictly monetary sense for the motorist naturally has other advantages by using the motorway, such as: saving in time, greater safety and lower mileage than on a normal road.'

Freeway systems in some of the larger metropolitan areas, Detroit, Los Angeles, etc. are designed to serve the 'city' traffic but are still lacking in a comprehensive approach. For example, while there is a growing awareness, the general tendency is to look upon the storage of vehicles at their destination as a separate responsibility, one to be taken care of by some other agency, not the governmental authorities. Also, there is still a division between freeway and mass transit advocates.

However, it seems that while it is not possible to apply one specific arrangement to all cities regardless of size, a majority of metropolitan areas in America have not yet reached the stage where a rapid transit network can be economically justified or, at most, only in certain directions where heavy population concentrations occur. It can be concluded, therefore, that in most American metropolitan areas a freeway system with express bus operation upon them would be a more suitable arrangement. It also follows that any such transportation plan must include and co-ordinate terminal facilities for both transit and other traffic.

Because of the high cost, freeway construction is in almost every instance considerably lagging behind traffic demand both in capacity and adequacy of design. The general tendency has been to have freeways terminate at the periphery of or skirt the central business district, more or less leaving the terminal problem to its own devices. This has resulted in ramp congestion and grade street congestion in the very areas where relief is most seriously needed.

It follows that providing terminals and, more particularly, providing well designed access to such terminals is an equally important part of any freeway system. Moreover, since for obvious reasons it is generally not possible to establish such terminal facilities within a block or two of the C.B.D. core area, that a further essential part of the transportation system is to provide an efficient, frequent, comfortable transportation system within the central business district itself, to serve motorists and mass transit passengers in journeying from their own transportation terminal to their ultimate destination.

We should not look upon the mass transportation system as one which necessarily should be financially self-supporting through the normal fare structure. It is no more logical to speak of a self-supporting transit system than of a sewage or major road network. Each is equally necessary to serve the community as a whole—it is not a service with which we can dispense. Surely no one will question the indispensibility of a mass transportation system in any large community. Is it not reasonable to suppose therefore that it might be handled in the same way as these other essential community services?

Conclusion

In the introduction to the findings of the Regional Seminars on Freeway Operation conducted by the American Institute of Traffic Engineers it is stated: '. . . it is not enough merely to build these freeways. Experience has shown that to deliver the promised safety, comfort and conveniences, the facilities must have a high level of operational attention. This responsibility — freeway operations — is new, complex and relatively expensive. It must be discharged efficiently if maximum dividends in transportation service are to be derived from the public investment in the freeways'. Also the concluding paragraph says: '. . . From theoretical research, empirical demonstrations and day-to-day experience in operating freeway facilities will come the added knowledge we sorely need today. From this added knowledge will come the future improvements in the still new field of freeway operations—improvements which will increasingly help to achieve the quality of transportation service expected . . . .'

Next Month

The paper presented by THE ROAD RESEARCH LABORATORY to the World Traffic Engineering Conference

Research into Highway Traffic Accidents

will be published in full.

BOOK REVIEW

Geometric Design of Modern Highways, by John Hugh Jones, M.S., M.Asce. E. & F. N. Spon Ltd., 63s.

RECENT motorway construction in this country has shown that our highway engineers have occupied the years when little construction was permitted with careful planning and the collection of traffic data, while the Road Research Laboratory of the D.S.I.R. has produced studies and developed techniques for use by practising engineers. The expansion of the road programme has resulted in many of the younger civil engineers being recruited for the work who, through preoccupation with projects other than highways, are unfamiliar with the material which has been collected over the years, and find it difficult to extract design principles in systematic form from the many individual published papers.

Similarly, students have difficulty in obtaining a clear pattern of the processes of traffic analysis and the layout of highways. United States textbooks and Federal and State agency handbooks have therefore been drawn on heavily, a practice which worries some American engineers as much as it might well give concern here.

The aim of Professor Jones in preparing this book is to present American and Continental practice in terms of British conditions. There can be no doubt that such a work was badly needed and that Professor Jones by virtue of his stay in this country is eminently qualified for the task. Those who met him or heard him lecture when in Britain will recognize in this book his enthusiasm and his dedication to the cause of advancing highway design.

The book is an excellent summary of American practice being more expository than the AASHO 'Policy' manuals and linking together elements of design in a logical development. It is wholly successful in presenting American practice, but one doubts whether those dangers are removed which may exist in using such practice in British conditions. Professor Jones might have used to advantage British references where they exist, especially as it is clearly stated that the book is intended to be used by engineers engaged in design. For instance, the meagre chapter on 'Road-user Benefits' quotes figures of costs and savings in United States cents when there is ample data for this country in the publications of the Road Research Laboratory and in the Proceedings of the Conference on Highway Needs of Great Britain (I.C.E. 1957) which might have been quoted in tabular form. No reference is made to the use of 'rate of return' as an alternative to the cost-benefit ratio. One appreciates the difficulties of space limitation but in the selection of designs, particularly intersection layouts, the cost-benefit analysis is the primary criterion and other matter (such as American vehicle data) could have been sacrificed in favour of so fundamentally an important chapter.

On the question of transition spirals there is no reference to the voluminous British data readily available to our designers, and the chapter on sign-posting ignores the valuable work of the Road Research Laboratory.

On the subject of capacity of junctions Professor Jones points out that traffic signal phases should be timed to suit the proportions of volume on each approach and refers the reader to a U.S. manual 'as a guide to warrants for signal control'. This is an instance where a reference to the Road Research Laboratory would have been a valuable substitution for anyone wishing to use this book as an aid to design, particularly when fixed-time signals are mostly used in the United States while vehicle-actuated systems are favoured in Britain. Some reference might have been made to the relationship of delays to volumes and speeds at intersections as this forms an important element in the economic comparison of designs and it is a subject on which there is excellent American work.

One would heartily agree with Professor Jones that there should be consultation with the town planner at an early stage in settling the line of a road. The trouble in this country is that the line of a road is often settled by the town planner without consultation with the highway engineer.

There are some obscurities and contradictions no doubt arising from the condensation of so much material, for example, when Professor Jones states that separation of entrance conditions to a motorway is a more critical problem than separation of exit conditions. Later he points out that personal injury accidents at exits are four times more numerous than at entrances. This may have nothing to do with separation but the point requires clarifying.

We are now well accustomed to photographic examples of American highways but Chapter 8 of this book is by far the most useful and valuable presentation we have seen. All the features of the photographs are carefully analysed and illuminated by excellent critical comment and more can be learnt from this chapter than from the drawings earlier in the book. It is a pity that in a book of this quality the publisher could not have arranged the photographs so that the text relating to each could be read simultaneously with examination of the illustration.

One might sum up by agreeing that the author has succeeded in his purpose of presenting American practice in a most excellent way but, as a guide to designers in this country, it would require to be interpreted with as much skill and experience as any other American handbook and the young student will require to continue to search the literature until the definitive manual of British traffic knowledge comes to be written.

R. White

ROAD RESEARCH 1960 *concluded from* 427.

'*Roundabouts with signals.* In in attempt to increase the stable capacity of roundabouts, signals have been installed on the approaches to four roundabouts which tend to lock in the peak periods. The roundabouts chosen were:

New York Road Circus, Leeds.
Greenford Road/Western Avenue, Middlesex.
Toby Jug Roundabout, Kingston By-pass, Surrey.
Gants Hill Roundabout, Essex.

'In each case the signals were installed between 100 and 200 ft. from the roundabout so that drivers, even though they had had a green signal, would approach with caution and would not expect a guaranteed free passage. Also it was intended that by setting the signals back drivers would observe the zebra crossings, which had to be retained as the signals were only operating during peak periods. Observations were made of the traffic behaviour, flows and delays before and after the installation with the following main results. Without control the roundabouts were observed to lock up with relatively low flows; on one occasion the Toby Jug Roundabout locked up with a flow of 3,600 vehicles/h. (observed over the previous 10 minutes) while at other times total flows up to 4,500 vehicles/h. (over a period of 10 minutes) have been recorded without a lock-up occurring. If 4,500 vehicles/h. is therefore regarded as the ultimate flow at this roundabout under free running conditions then there is a danger of locking when the flow exceeds 80 per cent of this figure.

'Under police control at the Toby Jug Roundabout, with all the approaches normally saturated, the highest flows recorded varied, depending on the particular policemen on duty, from 4,400 to 4,900 vehicles/h. (over a continuous period of 10 minutes). Under signal control the highest flows recorded were 5,200 (over 10 minutes) and were more consistent than under police control. The signal control therefore gave an increase in capacity of 12 per cent over the average police control, 16 per cent over the best free running (unstable) conditions and 45 per cent increase over the safe capacity under free running conditions. Rather fewer results were obtained at the Leeds and Greenford roundabouts but the general conclusions are much the same. At Greenford the increase over police control was about 8 per cent but at Leeds the capacity was about the same as with police control although with less variation. Free running conditions at these two roundabouts were more or less the same as at the Toby Jug. Results for Gants Hill are not yet available. Signal control thus gives about a 10 per cent increase in capacity over police control (and is less variable) and gives about half as much capacity again as under stable free running conditions. With the present signal settings, however, the roundabout is still liable to lock up in certain circumstances and an automatic extension to the "all-red" phase, based on the amount of congestion in the roundabout as measured by presence detectors, is being investigated.

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A.P.L.E. Conference Discusses

REVISED CODE of PRACTICE

THE draft revision of the British Standard Code of Practice on Street Lighting occupied the chief attention of those attending the Association of Public Lighting Engineers' Conference at Scarborough, October 2 to 4. Other matters which particularly concerned the delegates included changes in the standards and requirements of lighting since this year's President E. C. Lennox previously occupied the same office in 1936, and which he reviewed in his Presidential address. He laid particular stress on the saving in accident fatalities and injuries that could be effected with adequate lighting of traffic routes particularly motorways.

In opening the discussion on the Revised Code, G. Grime of the Road Research Laboratory drew attention to the new factors arising since 1937 which necessitated revised standards: the increase in traffic threefold at night, change in character of road surfaces and the more efficient light sources available. The principles underlying the original code remained but there were considerable alterations in methods and standards. These included improved methods of taking account of changes in the width of the roads, an extension of the mounting heights (instead of a single height there were to be four for Group A1—25, 30, 35 and 40 ft.), and changes in light distribution and geometry. The amount of light to be provided had been increased and the general effect would be a trend towards installations having about the same spacing as previously but with greater mounting height, more light and less glare. Greater flexibility of design was provided.

Mr. Grime pointed out that the minimum light flux per lantern was recommended but values quoted could not in all cases be obtained at present, and represented minimum requirements only. Use of non-cut off lighting would be substantially reduced.

Mr. Grime concluded by stressing that the draft had been put forward for comment which would be welcomed by the Committee responsible for its drafting and full consideration given to any made at the Conference before the definitive Code was accepted.

Comment there certainly was from the floor after Granville Berry, also a member of the Committee, had supplemented Mr. Grime's opening remarks. He stated that the revision was necessary because of the increase in traffic, its high density and the large number of accidents, particularly in proportion to vehicle miles at night. Under the present Code one in three accidents occurred at night although volume during darkness was reduced proportionately far more. Risk of death at night was two and a half times that in the day. He was confident that under the new Code the accident rate could be reduced as all evidence showed that good street lighting could reduce night accidents. The new Code represented a new conception of what was needed on the roads today in view of, among other things, the higher speeds and darker surfaces resulting from use of non-skid materials.

New Lamps or Old

Of the prepared papers presented to the Conference extracts appear below. H. Hewitt spoke on New Lamps or Old?

There were three main categories of lamps used in lighting today—incandescent lamps, discharge lamps, and fluorescent tubes, all producing a quantity of light which could be measured in lumens. They also produced a quality of light, which could be assessed but not measured. He continued: The four main characteristics which must be considered are:

(i) Efficiency of the lamp—in lumens per watt.
(ii) Life of the lamp—in hours of burning time.
(iii) Cost of lamp and the electricity it consumes.
(iv) Colour of light it gives.

Economic Considerations

If we are to make a comprehensive comparison of the total costs of buying and operating different lamps for a specific purpose we must have regard to four cost elements:

(i) The cost of the lamp itself—and its replacements over a period of time.
(ii) The cost of electricity consumed.
(iii) The cost of labour in replacing the lamp.
(iv) Other costs which may be incurred.

We shall need therefore the following information to assess the four cost elements:

(*a*) Lamp Cost: Actual price paid for lamps: Annual burning hours: Life of lamp:
(*b*) Energy Cost: Electricity tariff: Electrical loading of lamp, in watts: Watts loss in control gear: Annual burning hours:
(*c*) Labour Cost:
(*d*) Other Costs.

The gas lantern still standing in Scarborough beside the new Revo post-top fluorescent street lighting.

There are at least four other costs that ought to be taken into account, though circumstances make it impossible to include any but the first in making our present comparison:

(i) The cost of any control gear that may be necessary. Although this is regarded as a part of the capital equipment, it is so vital an economic consideration that an annual control gear allowance has been calculated, assuming a useful life of 15 years.
(ii) The need for housing this control gear may also influence the cost of the lantern or column.
(iii) The choice of one light source. This disparity in lantern costs may be great, e.g. a very simple lantern for an incandescent lamp compared with a lantern for fluorescent tubes.
(iv) The physical nature of a light source to some extent influences its usefulness. Because of the wide variety in lantern design, it is not possible to take account of the costs (ii), (iii) and (iv) in our comparison, but cost (iii) may sometimes invalidate a whole argument.

Suitability

We need lighting that is produced economically, but we also need lighting that is suitable, and the two considerations which chiefly determine the quality of street lighting provided by electric lamps are size and brightness, and colour.

On the question of glare we must remember that it cannot be assumed that because a lamp has a low brightness it will not cause glare, or that because a lamp has a high brightness it must cause glare. The observed area of the source is also a contributing factor.

A lamp of really high brightness is likely to be of small area and lends itself to optical control. Good lantern design could give both adequate distribution and reasonable freedom from glare. When discharge lamps were first developed we rightly regarded their relatively low brightness as an advantage, and we are perhaps apt to think of this as an essential characteristic of lamps for street lighting. This is not so, for if a source of equal efficiency could be developed which had high brightness, I think we would soon learn to control this brightness to good effect. The silhouette technique in street lighting has required that we should come to terms with glare. If, because of darker road surfaces we are to move towards cut-off lighting, then this problem of glare will be effectively dealt with.

So far as street lighting is concerned, it is possible to ask three questions:

(i) Will its colour help people to see better?
(ii) Will its colour rendering properties be pleasant?
(iii) Will its colour appearance be acceptable and/or useful?

The most important factor however, probably arises from the fact that the sodium lamp is inherently less glaring than other sources. This conclusion has been drawn by workers both in this country and abroad, and it is likely that the layman, not analysing his visual experience, says that he sees better because he suffers less glare.

LAMP CATEGORY 1

Providing up to about 3,500 lumens per point

Lamp Type and Rating	*Total Lumen Output of Lamp(s)*	*Inclusive Annual Cost of Providing 1,000 lumens for* 2,000 *hours*	4,000 *hours*
Incandescent 100 watt	1,200	8s. 10d.	11s. 11d.
Mercury MBF/U 50 watt	1,400	21s. 10d.	33s. 10d.
Incandescent 150 watt	2,030	25s. 3d.	36s. 8d.
Fluorescent MCF/U 2 x 20 watt ...	2,040	13s. 6d.	20s. 4d.
Sodium SO/H 45 watt	2,250	20s. 4d.	32s. 1d.
Mercury MBF/U 80 watt	2,600	17s. 4d.	26s. 7d.
Incandescent 200 watt	2,810	24s. 4d.	35s. 5d.
Fluorescent MCF/U 2 x 2 ft. 40 watt ...	3,040	13s. 8d.	20s. 2d.
Sodium SOI/H 45 watt	3,100	16s. 1d.	25s. 9d.
Fluorescent MCF/U 2 x 30 watt ...	3,240	12s. 3d.	17s. 11d.
Sodium SO/H 60 watt	3,420	15s. 6d.	21s. 6d.

(a) The use of incandescent lamps cannot be justified.
(b) If there is a job for the 100 watt incandescent lamp out of doors, it can be done better by the 50 watt mercury MBF/U lamp.
(c) The integral sodium lamp gives a higher light output and better value for money than the orthodox type.

LAMP CATEGORY 2

Providing from about 3,500 to 7,000 lumens per point

Lamp Type and Rating	*Total Lumen Output of Lamp(s)*	*Inclusive Annual Cost of Providing 1,000 lumens for* 2,000 *hours*	4,000 *hours*
Sodium SO/H 60 watt	3,420	15s. 6d.	21s. 6d.
Sodium SOI/H 60 watt	4,700	12s. 1d.	19s. 4d.
Mercury MBF/U 125 watt	4,700	13s. 8d.	20s. 7d.
Fluorescent MCF/U 2 x 4 ft. 40 watt ...	5,120	9s. 4d.	13s. 7d.
Fluorescent MCF/U 4 x 30 watt ...	6,480	12s. 3d.	17s. 11d.

(a) At the lower end of this scale we again note the dominance of the integral sodium lamp over the orthodox pattern.
(b) For 4,000 hours burning the 125 watt MBF/U lamp gives almost the same value as the integral 60 watt sodium lamp for the same light output. This is because of the higher price of the sodium lamp, its shorter life and its higher control gear loss. When one takes into account the colour distortion under sodium the mercury lamp would appear a good proposition.

LAMP CATEGORY 3

Providing from 7,000 to 15,000 lumens per point

Lamp Type and Rating	*Total Lumen Output of Lamp(s)*	*Inclusive Annual Cost of Providing 1,000 lumens for* 2,000 *hours*	4,000 *hours*
Sodium SOI/H 85 watt	7,400	9s. 5d.	15s. 0d.
Mercury MA/V 250 watt	8,750	12s. 6d.	18s. 4d.
Sodium SO/H 140 watt	9,100	9s. 11d.	15s. 5d.
Mercury MB/U 250 watt	10,000	11s. 1d.	16s. 3d.
Mercury MBF/U 250 watt	10,500	11s. 2d.	16s. 9d.
Sodium SOI/H 140 watt	12,200	7s. 5d.	11s. 7d.
Fluorescent MCF/U 3 x 80 watt ...	13,920	8s. 2d.	11s. 8d.

Again we see the poor performance of the orthodox 140 watt sodium lamp.
Although the uncorrected types of 250 watt mercury lamp have been included in this category, the corrected lamp gives comparable value with higher output and, better colour rendering.

Section of the outdoor exhibition of street lighting equipment.

Colour is no Bar?

The subject of G. K. Lambert's paper was 'Colour is no Bar'. Excerpts follow:

Before considering colour in street lighting it is desirable to clarify, as far as our limited knowledge permits, the complex answer to the simple question 'What is Colour?'

In modern physics our world reduces to a few elementary particles of matter or energy in a myriad of arrangements and speeds and spins, and electrical and magnetic fields which together form electro-magnetic radiation, which, in a narrow waveband from about .4 to .7 microns, has a photochemical effect on the retina of our eyes—it is the visible radiation we call light. We then see each wavelength characterized by a particular colour, the longer wavelength red and, as the wavelength decreases, the colour merging through orange, yellow, green, and blue to violet, the shortest visible wavelength. Colour appearance of a source is little guide as to how well its light will give coloured surfaces a true or pleasing appearance. The appearance of sodium light can be matched by metal filament lamps with an amber filter but the colour rendering of the two lights is vastly different.

The following notes should dispel any illusion regarding such a thing as true colour; they are intended to put the picture into perspective so that a balanced judgment can be formed regarding acceptable colour under various street lighting conditions.

(i) *Adaption.* Colour seen depends as much on the colour of light the eye is adapted to by previous viewing as on the colour of light being used, the observer rapidly becoming adapted.

(ii) *Gloss.* Where specular reflections occur, such as in the tail of the bright patch on a road surface, it is the colour appearance of the source which is seen.

Colour rendering did arouse strong feelings, but I think the general public have become reconciled to the use of sodium and uncorrected mercury lamps on traffic routes and are prepared to put up with their poor colour rendering properties in the interest of road safety. It is, however, when you consider the lighting of residential roads that the present situation becomes puzzling, for, despite the public's distaste for poor colour rendering, sodium lamps are now apparently acceptable to many local authorities.

Lamps for Street Lighting

Having assessed the various characteristics of electric lamps it would be useful to make a comparison of the total cost of operating a lamp for street lighting. Obviously this cannot take account of the qualitative factors, but it is possible to include within one schedule the cost of the lamp and its replacements, the cost of any control gear necessary for its operation, and the cost of electricity consumed. For this comparison lamps have been classed in four categories, according to lumen output. (Categories 1-4.)

General Observations

(*a*) The boundaries between these four categories have been drawn quite arbitrarily and other conclusions can be arrived at if other boundaries are chosen.

(*b*) All the comparisons emphasize the better value of the integral sodium lamp over the orthodox pattern, and of the colour corrected mercury lamp over the uncorrected type.

(*c*) Where the colour rendering is not so important as on main traffic routes, the high efficiency of the 200 watt sodium lamp is obviously of great advantage, and only a large reduction in the cost of the 400 watt MBF/U mercury lamp would make it a possible alternative for these roads.

(*d*) Where better colour rendering is desirable, however, particularly in residential roads, the fluorescent tube is a good alternative to sodium, chiefly because the overall efficiencies of the lower ratings of sodium lamp do not compare with those of the higher ratings.

LAMP CATEGORY 4

Providing more than 15,000 *lumens per point*

Lamp Type and Rating	*Total Lumen Output of Lamp(s)*	*Inclusive Annual Cost of Providing* 1,000 *lumens for* 2,000 *hours*	4,000 *hours*
Mercury MA/V 400 watt	16,000	10s. 2d.	14s. 9d.
Mercury MB/U 400 watt	17,000	9s. 7d.	13s. 11d.
Mercury MBF/U 400 watt	18,000	10s. 1d.	15s. 2d.
Sodium Linear 200 watt	18,400	6s. 9d.	10s. 7d.
Sodium SOI/H 200 watt	20,000	6s. 3d.	9s. 10d.
Sodium SOI/H 280 watt	22,400	8s. 1d.	12s. 7d.
Mercury MBF/U 700 watt	32,000	9s. 7d.	14s. 6d.

(*a*) *There is little justification for using the uncorrected types of* 400 *watt mercury lamp when such good value and good colour can be obtained from the type MBF/U.*

(*b*) *If, however, colour rendering is not of great consequence the* 200 *watt linear sodium lamp gives excellent value.*

(*c*) *The* 280 *watt integral sodium lamp, whilst giving a still higher output, loses something in overall value.*

(*d*) *If one wishes to go beyond the Code of Practice the* 700 *watt mercury MBF/U lamp could be considered, but a lantern containing two* 400 *watt lamps would have obvious advantages.*

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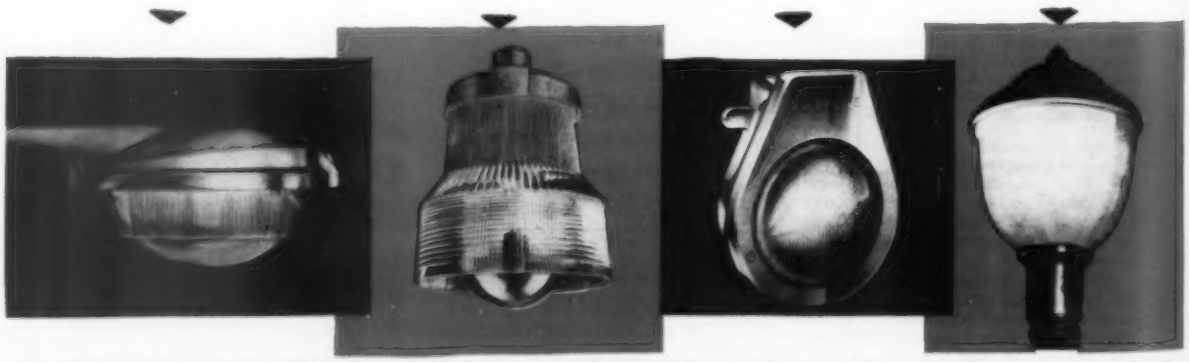

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(iii) *Brightness.* The visibility function applies only for a brightness of about 3 ft.L. and foveal (central) viewing. As brightnesses are decreased sensitivity to the blue end of the spectrum appears to depend mainly on whether the object is looked at directly (foveally) or obliquely; in the latter condition the night vision sensitivity curve applies. Sensitivity to the red end of the spectrum changes continuously with brightness level. Below 0.01 ft.L very little colour sensation remains.

(iv) *Size.* When the area of a light source of given brightness is reduced, colour sensation diminishes and at some size of source disappears. The sensation of red remains to a smaller size, the order of disappearance being first spectral blue, then green, yellow, orange and red. To give a sensation of colour a blue spot of light needs to be 7½ times as large as a similar red spot, though both can be seen without colour sensation when the size is further reduced.

(v) *Location.* Colour perception ceases at different angles varying normally from about 30° to about 60° from the direction of view depending on colour brightness level and area of what is being observed; green and red sensations fall off first, blue and yellow being appreciated to a slightly wider angle.

It can be demonstrated that a brighter light or light spot can be seen more rapidly than one of lower intensity. At the same brightness red light is seen more quickly than green or blue, and although the difference is quite small, (10 or 50 milliseconds), it varies the stopping distance for a vehicle travelling at 30 m.p.h. by 2-3 ft.

Colour in Street Lighting

Colour in street lighting can aid the motorist by making the scene natural and pleasant, enabling him to identify objects by colour when they are close. This is particularly important with signs not separately illuminated. The fact must, however, be faced that, at most present day street lighting illumination levels, the brightnesses of the scene are well below those at which colour is fully apparent. Specular reflection and shadow mask much of the surfaces which could be seen in colour, and over most of our roads a colour quality very much less than that demanded indoors is all that is justified. Colour appearance of the lighting units is the most noticable effect and this in street lighting is probably of the greatest importance.

With its high efficiency of light generation and its advantages in promoting visibility, sodium lighting is eminently suited for traffic route lighting. It is acceptable too in built-up routes of lower amenity value and is becoming increasingly popular for Group B roads where traffic is increasing e.g. on bus routes. It is being used in Bolton mixed with metal filament light and in Western Germany with colour corrected mercury lamps to give some improvement in colour for city centres.

Because colour sense is poor at street lighting brightnesses, and colour is often masked by shadow or by specular glints, and because the mind tends to supply colour sensation, it is colour appearance at lantern brightnesses which matters most. Attempts to improve colour appearance by mixing with light from other sources is ineffective if the individual source colours can be seen; the light must be mixed in the lantern. Filament lamps (GLS) add a continuum containing a preponderance of red which is lacking in the sodium light, but the filament lamps are relatively short lived and bring the overall efficiency of light production down. They afford some improvement in colour appearance but not so much as might be expected; the real improvement is in colour rendering at high illumination intensities.

The higher efficiency colour corrected mercury lamps (MBF) have the advantage of more apparent blue which balances the yellow of the sodium, but the resultant colour of the mixture may be rather unattractive. The MBF bulb shape does not facilitate light control, nor mixing with light from the linear source. The former is not so important in town centres. A colour appearance close to that of metal filament or warm white fluorescent light can be achieved using a blue-green tubular fluorescent lamp with the advantages of high efficiency and effective mixing. The colour appearance point of such a fluorescent lamp is on the opposite side of the colour triangle from that for sodium and by using the Maxwell centre of gravity colour mixing rule the right proportions of sodium and blue-green fluorescent light can be determined. Colour rendering at the brightness levels of street lighting scenes may be considered quite acceptable.

Uncorrected mercury has fallen out of favour for new installations: colour corrected mercury (MBF) is being used extensively where colour is considered important. Its efficiency is good (42 lm./W) and colour rendering acceptable at street lighting brightness, but appearance is greenish and sometimes difficult to distinguish from uncorrected mercury (MA). Adequately large lanterns, preferably with some degree of cut-off, give results which are quite acceptable where surroundings are good, but are a little stark in industrial surroundings or where new roads have been constructed and backgrounds are negligible.

The best colour appearance and rendering of all is from tubular fluorescent lighting. The lamps are economical in cost and power consumption, although the first cost of the lanterns is high this is not a large proportion of the total cost of the installation. Due to the low brightness of the source the light flux which is available from a lantern of reasonable size is limited; there is a tendency to try and get too many lamps in, with the result that the lantern is flashed in all directions whereas some degree of cut-off would be better. Lack of cut-off is tolerable only because of the low brightness of the lamps, especially where there are good backgrounds as in shopping areas. Where high light intensities are required, close spacing is desirable and wall mounting has advantages aesthetically and economically. Lamps of higher loading even if at first of poorer maintenance than the standard 80 watt rating, which has been improved over a period of two decades, could help in providing more light from reasonably sized lanterns.

Traffic Routes

Code of Practice traffic route lighting is exemplified by the considerable mileage of road 26 to 44 ft. wide lit by 140 watt SO/H lanterns at 25 ft. mounting, 120 ft. spacing, staggered, and 30 ft. between rows of lanterns. Most of the lanterns have a medium angle beam light distribution with the peak intensity at 75° to the downward vertical (D.V.) and cut-off to half peak intensity at around 86° D.V. Such lighting was adequate for moderate traffic in good weather but rather glaring with some modern road surfaces which are rough and so have not a high preferential reflectivity to light at angles of around 86° D.V. Such an installation gives 6,000 lm./100 ft. linear in the lower hemisphere. Better lighting can be achieved by using lamps of higher output (20,000 lm.) at 30 ft. mounting height with the same spacing and arrangement but with cut-off light distribution.

When more economical lighting is needed on dual carriageways, with the minimum clutter of columns and lanterns, the 20,000 lm. sodium lamp has been used in pairs opposite, on outer verges only or behind cycle tracks where they exist, at 35 ft. mounting height, 170 ft. spacing. It provides just over 7,000 lm./100 ft. linear per carriageway. Where colour is not so important as safe flow of traffic or where shop window lighting provides an element of good colour for the pedestrian, sodium is frequently used. When colour is considered more important the more expensive colour corrected mercury (MBF) lighting is becoming increasingly used, and has been strongly supported by the Civic Trust Architects, who seem to like the daytime appearance. The author has looked at many installations and prefers the night-time results where the larger cut-off or semi-cut-off lanterns are used. The new Group A lighting in Birmingham is an outstanding improvement on the previous pre-war lighting; fully cut-off 400 watt MBF lanterns are used at 30 ft. mounting height, 90 ft. spacing in staggered arrangement. Smaller, non-cut-off MBF lanterns appear rather harsh and glaring and many of the installations seen have been in locations where provision of good colour is not rewarded.

Summary

With its high efficiency of light generation, long life and suitable size and brightness for light control in a street lantern of reasonable size, the sodium lamp is unequalled for traffic route lighting. Because of changes in human vision over a wide brightness range, its colour, which at first sight would seem to bar its use, turns out to be less glaring at lantern brightnesses and to give greater clarity of vision at road brightnesses. For the motorist the resulting confidence in seeing in a good installation far outweighs the initial disadvantages of unaccustomed colour.

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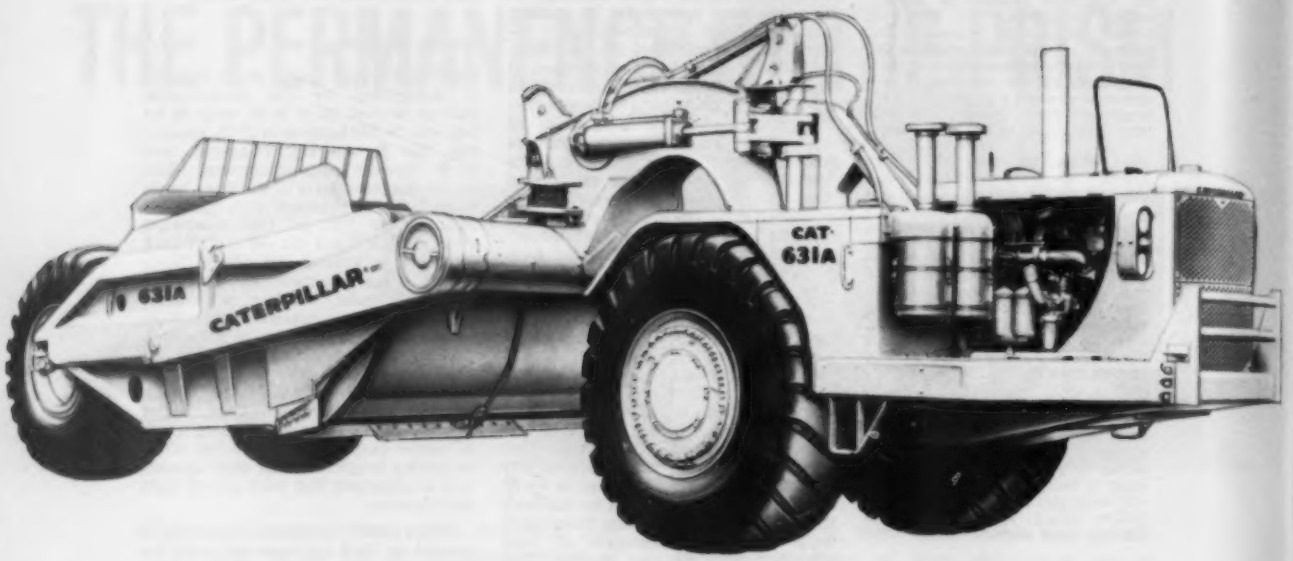

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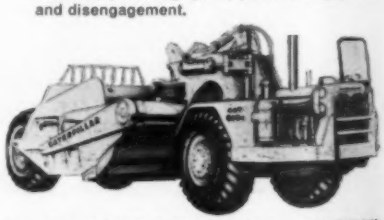

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Fig. 1. Hume Highway, Tallarook, Australia, with rubber in the binder on the left side and without it on the other.

RUBBER IN ROADS

by A. R. Smee, *C.B.E., M.I.C.E.*

THE precise technical information now readily available regarding rubber has enabled the engineer in post-war years to employ with confidence this most versatile of materials to an ever increasing degree and in an ever increasing range of application, among which transport and highway engineering occupy a prominent place.

Rubber is of course a key material in road vehicles—a large modern car may contain upwards of 300 rubber components—while one of the most revolutionary and popular of small cars is entirely, and very successfully, sprung on rubber. These facts are known to all, but rubber is also used on the highway itself and among such uses is the so-called 'rubberized road' which is gaining the attention of highway engineers in all parts of the world and which offers some attractive features.

In pre-war years some experimental road sections were laid having a running surface actually of rubber, they were in fact composed of rubber capped concrete blocks. They proved almost infinitely hard wearing, pleasant to walk on and deadened noticeably the noise of traffic but, they had two disadvantages, they were costly to lay and, in wet weather, did not provide adequate tyre grip for present day braking requirements. The modern rubberized road is entirely different in conception and looks and feels like any other black top road surface, it is in fact a normal road surfacing plus the addition of a small percentage of natural rubber into the tar or bitumen used as the binder.

The rubber used is either latex, that is, liquid rubber from the tree generally containing some 40 per cent of water, or one or other of the specially prepared rubber powders which are available. The proportions used are generally 1-2 per cent by weight of rubber to weight of binder for a surface dressing or 4-5 per cent by weight of rubber to binder for a pre-mixed asphalt type surfacing. The rubber is blended into the tar or bitumen by heating and agitation to form a rubberized tar or rubberized bitumen as the case may be. Where a bituminous emulsion is concerned latex can be added by simple mixing or co-emulsification.

The effect of the small rubber additive is marked and a rubberized binder shows noticeable elasticity, reduced temperature susceptibility and exceptional adhesion. In road practice this means less tendency for the surfacing to crack under foundation or sub-soil movement, less tendency to soften and 'fat-up' in hot weather, with reduced brittleness in extreme cold and better chip retention on surfaces newly opened to traffic and where laid under adverse weather conditions.

The flexible and elastic properties of a rubberized binder are of course particularly valuable on low cost roads laid on non-rigid foundations where some deformation may be anticipated but, even over re-inforced concrete foundations, a rubberized surface can be advantageous in reducing the reflected cracking which often comes through to the surface from the joints in the concrete slabs. In a surface dressing, that is where the road is sprayed with tar or bitumen and then coated with chippings, the chippings should stand proud of the binder and vehicle tyres should get their grip on the stone surface. Where a surface fats-up or bleeds, the tar or bitumen softens and swims up over the surface. A fatted-up surface becomes smooth and slippery with, of course, a potential risk when wet or in an emergency. A rubberized binder with its higher softening point is less liable to trouble of this nature.

Only those who have actually worked on a road resurfacing project know how reluctant the ordinary road user is to comply with notices appealing to him to slow down. As a consequence, flying chippings from a newly laid

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AP 122

Fig. 2. Werribee By-Pass—Duncans Road Overpass sealed with rubberized bitumen.

surface dressing are commonly a nuisance and can be an actual danger—a half inch chipping flung from the wheels of a speeding car may well damage a windscreen with its attendent dangers. Although difficult to prove, it is generally remarked that with a rubberized surface dressing whip-off of chippings is considerably reduced.

'Rubberized roads get the tough jobs' is rather more than a slogan, it is a simple statement of fact. Rubber is an additive to a road surface and any additive has to be paid for. As a result this higher priced surfacing is mostly used where conditions are difficult, stresses are high and where it is desirable to keep road repairs to a minimum. Steep hills, roundabouts, bus stops, unstable roads over ground liable to subsidence, taxiways for turning aircraft, these are the conditions under which the rubberized surface is proving a good investment and helping to keep the traffic moving. Muswell Hill, one of the steepest gradients in London has a rubberized surface as has Porlock Hill in Somerset—one of the steepest hills in the British Isles, and, further afield, a city road in Altoona, Pennsylvania, where rubberized asphalt has been laid over an old cobblestone surface with a gradient of 1 in 5.5. The first section of Birmingham's new Inner Ring Road (Fig. 3), the taxiways at Essenden Airport, Australia; the main trunk road out of Durban in South Africa—so the list goes on.

Rubber, however, plays an important part in highway safety and maintenance as well as being an additive to the actual road surfaces. The cats-eye, surely one of the greatest blessings the fog-bound motorist knows, depends upon rubber for its operation, while white rubber-based paint filled with minute glass beads—ballotini—provides hard wearing white lines which give a helpful sparkle to the night driver.

From New Zealand comes the aptly named 'judder bar'. Used at road intersections and such like they are of size and shape rather like the ridges in a sheet of corrugated iron but more widely spaced and are laid within the white painted areas used to delineate traffic lanes, their purpose being to stop the motorist from the irritating, and sometimes dangerous habit of 'swinging wide'. The ridging used for this purpose needs to be resistant to impact and a rubberized asphalt mix was used. The first reaction on the motorists' part was reported to be one of indignant complaint at being severely shaken up and his second, to keep to his proper lane and avoid the juddering. It would seem to have possibilities.

A modern and notable use for rubber is in connection with bridge bearings. The bridge, if of any size, has to be allowed some freedom of movement to take up expansion and contraction and the steel roller bearings commonly used call for periodic maintenance while the rollers themselves, due to their small movement, tend to wear flats. The sandwich type rubber bearing interleaved with steel plates is the answer to this problem and is coming into wide use on new road construction, once installed it needs no further attention.

A further problem in connection with bridges, is, of course, the expansion joint which has to be left across the width of the roadway to allow for the movement of the bridge. The difficulty has been to provide a filling for the joint which will not hump up and form a raised ridge across the road in hot weather as the bridge expands and the gap closes. Recent developments suggest that this problem can also be overcome with the aid of rubber.

This article was prepared specially for TRAFFIC ENGINEERING & CONTROL *by The Natural Rubber Bureau.*

Fig. 3. New Inner Ring Road, Birmingham, topped with a wearing course of red rubberized asphalt dressed with ½ in. pre-coated chippings of the same colour. The base course is also rubberized.

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INDUSTRIAL NEWS and INFORMATION

A.P.L.E.
Exhibition Review

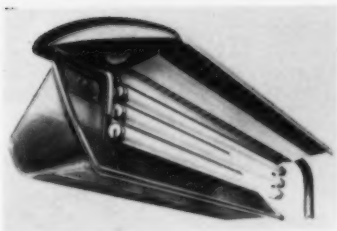
Abacus Municipal Ltd.
The complete range of Abacus Group 'A' and Group 'B' columns shown at Scarborough is approved by The Council of Industrial Design and conforms to the British Standard specification. Some of the designs were previously manufactured by The North Midlands Engineering Co. Ltd., and were known as the 'Normid' range. In the design of all the columns, particular attention has been paid to appearance, whilst a high technical standard has been maintained, the basis was a slim column, robust in every way but capable of withstanding normal hazards to which street furniture is subjected. The metal gauge is heavier than that usually used in the manufacture of steel lighting columns and will not normally collapse on impact but will merely bend. The columns can be arranged for any mounting height, although the standard heights are 25 ft. for Group 'A' and 15 ft. for Group 'B'. A wide range of brackets is available to suit all makes of lanterns. Bases are supplied with a door fitted with a tamperproof lock, and the door openings are sufficient to take time switches and control gear.

These columns are guaranteed for life providing the makers supply, erect and paint initially and maintain their own columns for a small annual sum.

T.E.C. 240 for further details

A.E.I. Lamp and Lighting Co. Ltd.
The Mazda 200 watt sodium linear lamp and the Amberline range of lanterns were prominently featured on this stand. This partnership is now accepted as a practical solution to the problem of achieving higher lighting intensities for Group A roads and yet without increasing the installation and maintenance costs. There are now three lanterns in the Amberline range—spigot-entry medium angle beam, side-entry medium angle beam and side-entry cut off. Another application for the Mazda sodium linear lamp has been created by the introduction of the M 30 floodlight, a valuable supplement to normal street lighting during periods of poor visibility at accident black spots.

Two new Amber lanterns introduced this year are a side-entry version of the Baby Amber for Group B roads, using



Refractor version of the A.E.I. Kingston lantern.

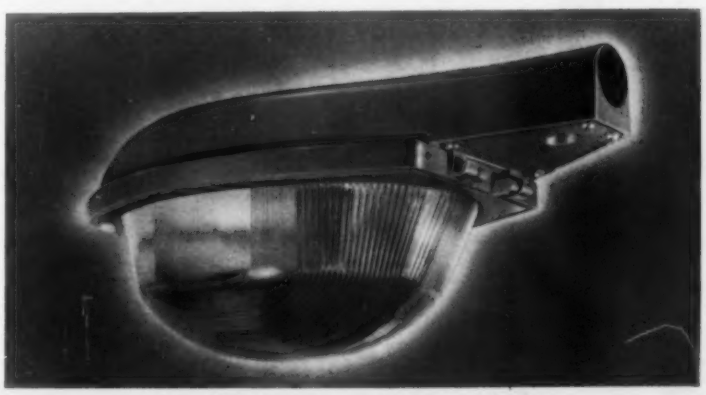
a 45/60 watt sodium lamp, and a side entry enclosed lantern using a 140 watt sodium lamp for Group A roads. Also being shown were: a new refractor version of the Kington lantern for three 80 watt fluorescent lamps: the Kuwait reflector type lantern for three 5 ft. 80 watt fluorescent lamps, with a non-cut-off medium angle beam distribution suitable for Group A lighting: the Carpenter reflector type lantern for four 4 ft. 30 watt fluorescent lamps, with a non cut-off medium angle beam distribution suitable for intermediate road lighting at 18/20 ft. mounting height.

T.E.C. 241 for further details

Atlas Lighting Ltd.
The Atlas Alpha Seven—an entirely new lantern for Group A lighting—was shown for the first time at the Exhibition. Using a 250 or 400 watt colour-corrected mercury type MBF/U lamp, the Alpha Seven uses a one-piece cast light alloy body which combines end-support and Opticell in one unit, with a smooth outer glass refractor bowl hinged to give easy access to the interior. The internally moulded prisms of the refractor bowl are designed to give a concentrated beam of high intensity at leak level.

Another recent addition to the Atlas street lighting range is the Alpha Five Group A sodium lantern. This lantern uses the 200 watt linear sodium lamp, which is designed to supply the higher lighting levels demanded by the steadily increasing traffic on the roads. The Alpha Five takes full advantage of the characteristics of the linear sodium lamp providing a good distribution with the sharp run back from the peak now considered desirable to minimize glare. The canopy of the lantern is an aluminium pressing, with an internal aluminium support casting. The acrylic bowl, with its sealed refractor panels, controls the light emitted in all directions below the peak and provides a smooth transition from peak intensity to the reduced value in the vertical sector.

An interesting item, newly included in the Atlas range of outdoor fittings is a miniature fluorescent bulkhead fitting. Weatherproof and protected against



Atlas Alpha Seven lantern for Group A lighting.

TEC494 *for further information*

REVO

lighting goes to the front

Photo by kind permission of C. Anderson, M.I.E.E., M.Inst.F., Borough Electrical Engineer and Manager, Douglas Coporation Electrical Dept.

The impressive two mile long sweep of Douglas, Isle of Man promenade is shown here brilliantly illuminated by Revo Helion lanterns (shown top left) specially developed for this scheme.

Lighting the promenade of a seaside resort involves a number of problems not usually encountered in normal street lighting. The road surface must be exceptionally well illuminated especially during the holiday period. True colour representation is most important. A bright spectacle must be provided without detracting from the effect of other purely decorative lighting. The lanterns must be decorative both when lighted and during daylight and must withstand the effects of storms and sea spray. During the winter provision for the reduction of the lighting to normal standards must be made. All these conditions have been satisfied by the Revo installation at Douglas and has received widespread approval from residents and visitors.

REVO ELECTRIC CO. LTD.,
TIPTON, STAFFORDSHIRE

W & W

corrosion, this fitting (Cat. No. LB 2008) has a sturdily built aluminium alloy body and plastic diffuser housing control gear for two 12 in. 8 watt fluorescent tubes, either in series or parallel. The reflector assembly is easily removed for cleaning or maintenance.

T.E.C. 242 for further details

A Horstmann time switch.

The Horstmann Gear Co. Ltd.
A comprehensive range of time switches was seen on this stand, including hand wound models (15 and 40 day run), electrically wound models, and synchronous models with or without spring reserve.

The latest synchronous type 'V' Mark II time switch which incorporates a three-day spring reserve, was featured. This has a capacity at 250 volts of 30 amps. A.C. and a large number have already been supplied for the control of street lighting overseas. It can be fitted with a solar dial and the makers claim that it maintains extremely accurate time keeping. Other switches worthy of attention include the popular types 'K' Mark II and 'Y' Mark II. The former is a synchronous motor driven unit while the latter is electrically wound and incorporates a 12-hour spring reserve. Both are small compact switches which will readily fit into the bases of modern lamp columns where space is normally limited. They can be supplied in moulded boxes or with push-on clear moulded covers. The capacity of each at 250 volts is 20 amps. A.C.

T.E.C. 243 for further details

Painter Bros. Ltd.
This company showed a completely new design of three-sided column, with tapering profile and triangular cross section. The construction of this new column, called the Triad, is in accordance with B.S. 1840:1960, employing $\frac{1}{8}$ in. mild steel, jig welded. All columns are hot-dip galvanized after fabrication to give protection both inside and out.

A wide range of lantern brackets for single or double fitting is available, especially designed to be in keeping with the appearance of the column, which is supplied complete with a flush inspection door and equipment panel mounting. Any other special fittings such as ladder arms can be supplied on request. Heights to light source can be varied from 15 ft. up to 35 ft. or by special arrangement heights outside this range can be supplied as required.

T.E.C. 244 for further details

Simon Engineering Dudley Ltd.
On this stand two Simon Hydraulic Platforms were displayed the L.25 model, mounted on a Land Rover, and the P.30B model, mounted on a B.M.C. 3-ton chassis.

The L.25 is the smallest in the range of Simon Platforms, extending to a working height of 26 ft. (7.92 m.) and an outreach of 13 ft. 6 in. (4.11 m.). It is an ideal size for a large circle of users who cannot make full use of larger models. One of the main advantages is that it can be mounted on a smaller carrying vehicle than is required for the bigger models, thus providing the same complete mobility with less capital outlay. It can be mounted on any 30 cwt. (1,425 kg.) capacity chassis of conventional design with a wheelbase of approximately 10 ft. (3.05 m.). It can also be mounted on an electric truck, a trailer or a hand-drawn trolley.

A Simon platform was also displayed by Dennis Brothers of Guildford—an I.G40 model mounted on a Dennis chassis.

T.E.C. 245 for further details

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Telephone Manufacturing Co. Ltd.
The Capacitor Division of Telephone Manufacturing Co. Ltd., exhibited their wide range of power factor correction capacitors.

The trend towards even slimmer

The new Triad column.

lighting columns makes the provision of compact components increasingly important and displays on the TMC stand emphasized the comparatively small size of their street lighting capacitors and the adaptable method of mounting them. One display panel showed how the new TMC fixing bracket provides a wide choice of mounting positions, enabling the capacitor to be placed conveniently in the space available.

The size of the capacitor is naturally dependent on the capacitance value. The smallest capacitor in the TMC street lighting range (8 microfarad) has a height of only $2\frac{1}{4}$ in. the largest (25 microfarad) measures $6\frac{1}{4}$ in. and all possess a cross-section not exceeding 3 in. x 2 in. Another display featured a sample of every capacitor made by TMC for street lighting use. These are available in three distinct types covering working temperatures of $-40°$ to $+$ 60°C., $-5°$ to $+$ 60°C., or $-25°$ to $+$ 50°C., according to the impregnant used.

T.E.C. 246 for further details

A Simon P.30B hydraulic platform.

TEC695 for further information

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EXTENDIT

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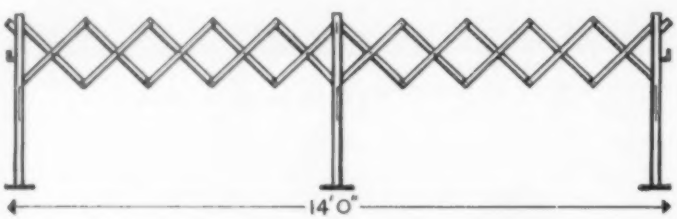

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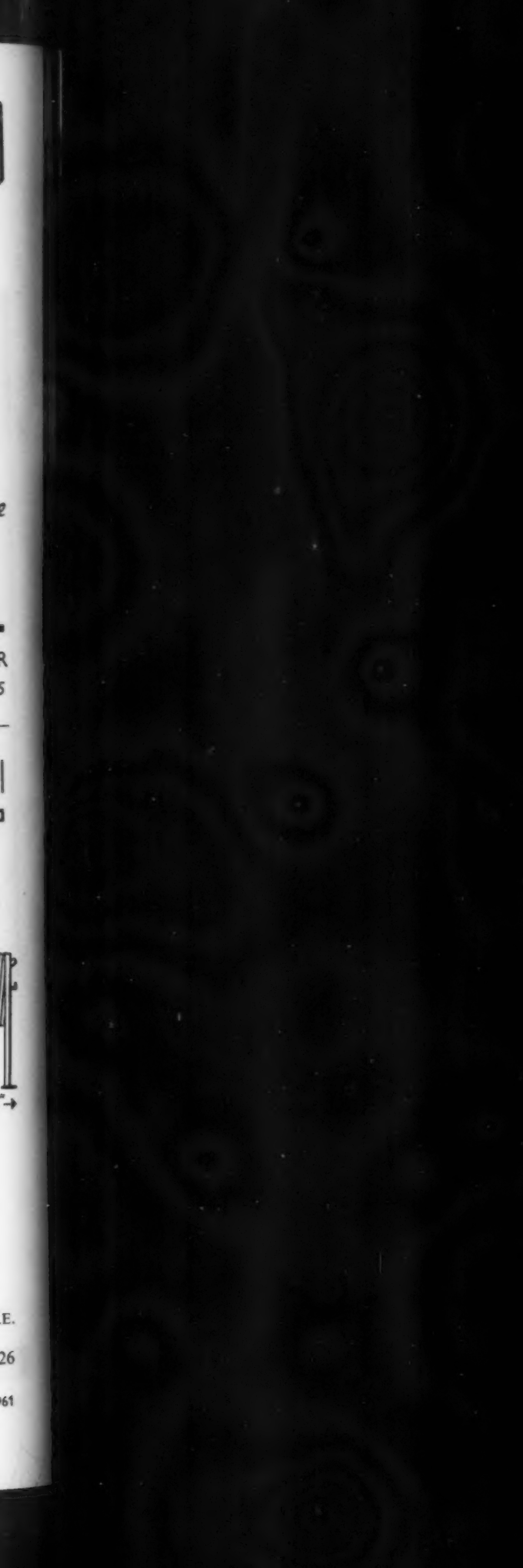
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